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Stratigraphy of the Devonian Trimmers Rock in Eastern Pennsylvania

Lawrence A. Frakes

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BULLETIN G 51

Stratigraphy of the Devonian Trimmers Rock in Eastern Pennsylvania

by Lawrence A. Frakes
Cooperating Geologist

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FOREWORD

This publication deals with a stratigraphic problem involving complex sedimentological processes and varied paleo-environments. The approach which the author used involved quantitative and semi-quantitative laboratory methods coupled with field observations. Some of the stratigraphic observations and conclusions are by their very nature subjective and thus, subject to variation depending on the individual observer. We believe that this is one approach to the understanding of a difficult geological problem.

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STRATIGRAPHY OF THE DEVONIAN TRIMMERS ROCK IN EASTERN PENNSYLVANIA[1]

by
Lawrence A. Frakes[2]

ABSTRACT

The Trimmers Rock Member of the Fort Littleton Formation attains a maximum thickness of about 4000 feet in Pennsylvania and consists of gray, brown, and green shale; graded, fine-grained graywacke; and conglomerate of Middle and Late Devonian age. The Trimmers Rock and its lithologic counterparts are exposed throughout the Valley and Ridge province of the central Appalachians where they represent relatively deep-water marine deposits of the Catskill delta.

The Trimmers Rock of eastern Pennsylvania is divisible into ten informal rock-stratigraphic units consisting dominantly of siltstone and separated by nine shale units. Graywacke units thicken and coarsen to the south-southeast. The five youngest siltstone units are lateral equivalents of the lower portion of the shallow-water Catskill Formation, which is progressively older toward the southeast. The oldest siltstone unit is identical to the upper portion of the Middle Devonian Mount Marion Formation in southeastern New York.

Within this detailed stratigraphic framework, the geographic distribution of physical features allows generalizations to be made concerning the paleogeography of the Catskill delta. The foot of the submarine paleoslope is delineated by the lowest occurrence of subaqueous slide deposits consisting of angular blocks and depositionally loaded structures. This Devonian paleoslope was inclined from south-southeast to north-northwest in eastern Pennsylvania and built north-northwest through time. Throughgoing palcocurrents from the east deposited distinctive graded siltstones against the foot of the slope. In south-central Pennsylvania a slightly younger paleoslope was probably inclined from southeast to northwest.

East-west ripple marks indicate that paleoccurents moved generally northward in their early stages but were deflected at the foot of the paleoslope to the westward flow indicated by sole marks. In south-central Pennsylvania, analogous counter-clockwise deflection of early northwest flow to later southwest flow is suggested by less abundant structures.

The floor environment during deposition of the Trimmers Rock was characterized by 1) stable slopes inferred from the lack of slide deposits, 2) relatively low-energy currents forming sole marks, 3) abundant infauna inferred from ubiquitous trace fossils and poorly developed fissility in shales, and 4) low or infrequent oxygenation suggested by the nature of the fauna and the dark colors of the rocks. The depth was possibly deep neritic.

The slope environment was characterized by 1) locally unstable slopes indicated by slide deposits, 2) relatively high-energy currents inferred from abundant cross stratification, ripple marks, and fragmented fossils, 3) a more common epifauna and fewer infaunal elements, and 4) high or frequent oxygenation indicated by the fauna and the abundance of hematite.

The graywackes and conglomerates of the Trimmers Rock are notably deficient in feldspar and contain few recognizable igneous or metamorphic rock fragments. This suggests that the source region was a broad sedimentary terrain of modcratc relief occupying portions of the present Great Valley, Piedmont, and Coastal Plain.

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[1] Submitted to the faculty of the University of California, Los Angeles, in partial fulfillment of the degree of Doctor of Philosophy, June, 1964.

[2] Assistant Research Geologist, University of California, Los Angeles.

INTRODUCTION

GENERAL STATEMENT

The earliest attempts by geologists to subdivide the thick column of Paleozoic sedimentary rocks of the Appalachian region succeeded in separating an upper sequence of dominantly clastic deposits from a lower one of considerable carbonates. The carbonate-clastic dividing-line is at the top of the Lower Devonian Onondaga Limestone.

Within the upper clastic section further lithologic and biologic subdivisions of varying degrees of lateral persistence have allowed generalizations to be made about the geologic history of the Appalachian geosyncline. Among the most significant of these is the recognition of the deltaic nature of the Middle and Late Devonian suite of rocks. The Catskill delta, consisting of a complex of deep- and shallow-marine sedimentary rocks in intricate facies relationships, is probably the most intensively studied structure of its kind.

This study is concerned with the nonred, arenaceous Devonian strata of eastern Pennsylvania and nearby areas. This group of rocks is embodied in the Trimmers Rock Member of the Fort Littleton Formation, which attains a maximum thickness of about 4000 feet. It is hoped that study of the physical characteristics of these deltaic rocks will yield recognition criteria which will be of value elsewhere. One purpose of the present study is to define and test the value of lithostratigraphic units in the deep-water Trimmers Rock facies of the Catskill deltaic complex.

Slide structures, indicating unstable slopes, provide much information bearing on bottom configuration, as do the paleocurrent systems, which trace the paths of gravity-driven currents. Stratigraphic and geographic variation of lithologic features determine the distribution of paleo-environments and paleogeographic elements.

REGIONAL GEOLOGY

The geologic column of Middle and Upper Devonian rocks in Pennsylvania (modified from Willard, 1939) is generalized in Figure 1. In most sections the Marcellus Formation overlies the Onondaga Limestone and is in turn overlain by the Mahantango Formation. The base of the Upper Devonian section is drawn on the base of the succeeding Tully Limestone Member of the Rush Formation. A series of dark shales, the Burket Member of the Rush Formation and the Harrell Shale Member of the Fort Littleton Formation, occur above the Tully. The arenaceous portion of the Catskill delta lies above these shales; a relatively deep-water facies is represented by the Trimmers Rock and Brallier Members of the Fort Littleton Formation, and a shallow-water facies is represented by the red beds of the Catskill

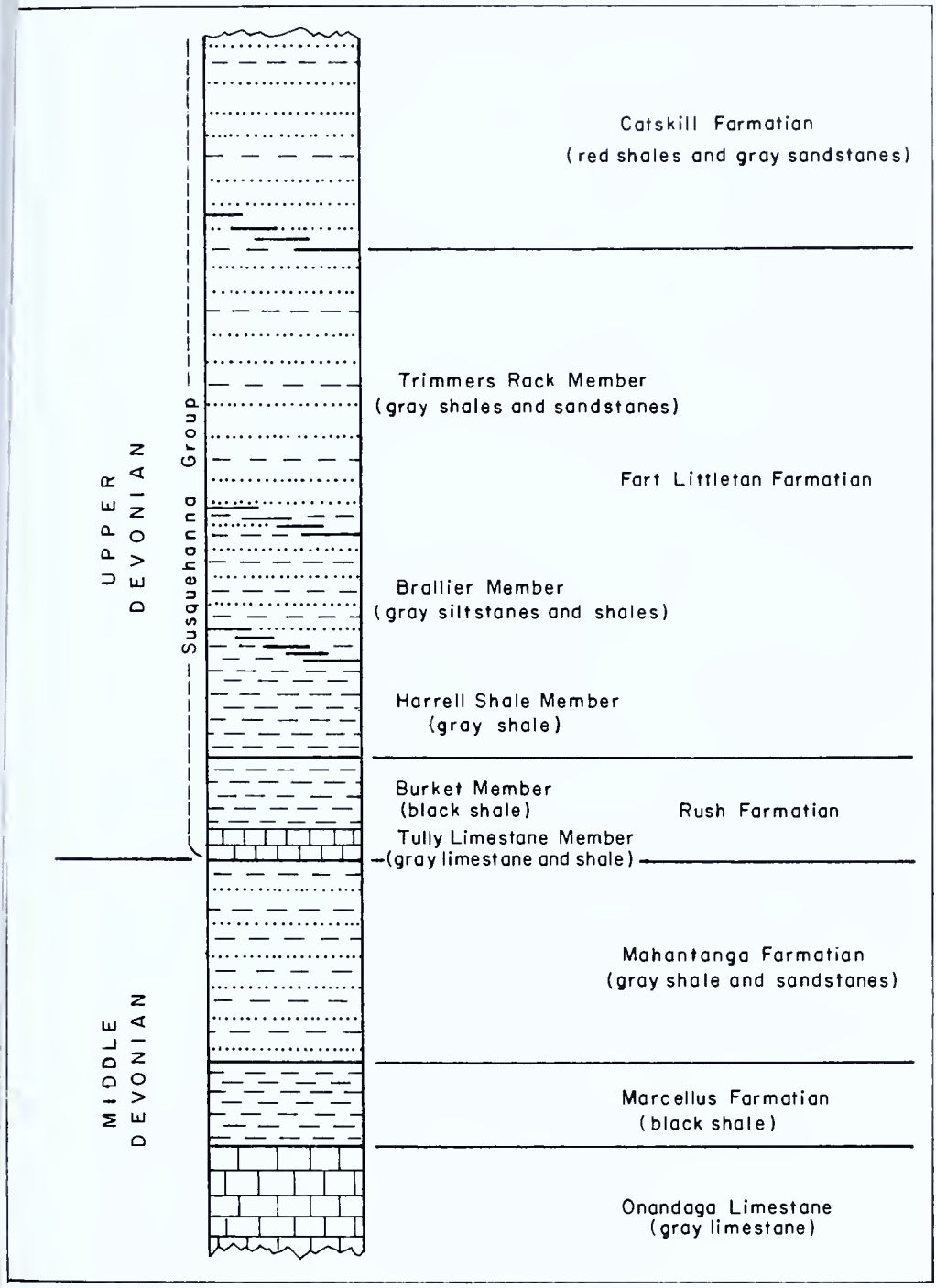

FIGURE 1. Generalized geologic column of Middle and Upper Devonian Rocks in central Pennsylvania.

Formation. Regionally, the shales, deep-water sands, and red-bed sands interfinger in well-defined facies relationships which indicate that the shallow-water deposits built northwestwardly over the deep-water deposits (Willard, 1939).

The Trimmers Rock Member of the Fort Littleton Formation, the subject of this study, has widespread surface exposure in southern and eastern Pennsylvania (Figure 2). In the Valley and Ridge province the Trimmers Rock is best exposed in the many stream valleys transverse to the regional structure. Exposures of the Trimmers Rock in eastern Pennsylvania are greatly restricted because of glacial cover.

Regionally, strata having the lithologic characteristics of the Trimmers Rock extend past the boundaries of Pennsylvania into south-central and southeastern New York, western Maryland, and eastern West Virginia.

For the purposes of the detailed lithostratigraphic studies undertaken here, reasonably complete sections are necessary. Exposures along the Allegheny Front and in the northern half of the state are meager, and for this reason the study is restricted to the region broadly referred to as southern and eastern Pennsylvania. Sections exposed at Port Jervis, New York are included for the purpose of giving maximum coverage in an easterly direction, and four wells in northeastern Pennsylvania provide data on rock distribution toward the northeast.

ACKNOWLEDGEMENTS

My sincere gratitude is expressed to Professor John C. Crowell, who inspirationally guided the research. The substance of this report owes much to his excellent judgement and wide experience.

Thanks are extended to W. R. Wagner for freely allowing use of his sample descriptions from the wells in northeastern Pennsylvania and to numerous geologists for discussion and information on the regional geology. I am grateful for numerous suggestions offered by J. Douglas Glaeser, N. L. McIver, F. B. Van Houten, and E. L. Winterer, but the interpretations and conclusions of this study are my own responsibility.

Appreciation is expressed to Mrs. Opal L. Kurtz and Albert Van Olden for the drafting and to Lowell Weymouth and Edwin K. Koppe for assistance with the photographic work.

The field work for this study was supported by the Bureau of Topographic and Geologic Survey of the Commonwealth of Pennsylvania and by the 1963–64 Richfield Fellowship at the University of California, Los Angeles.

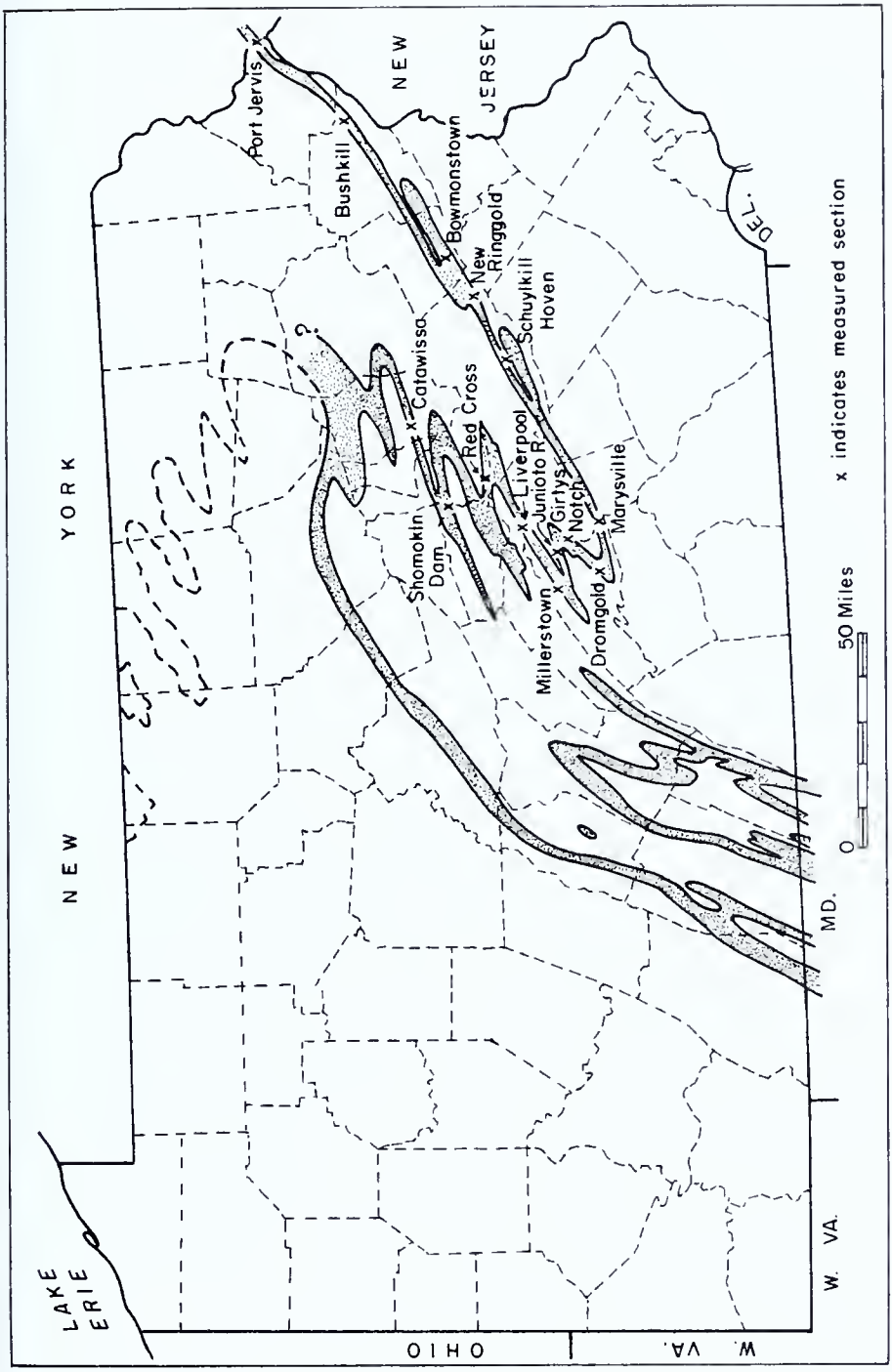

FIGURE 2. Distribution of the Trimmers Rock Member of the Fort Littleton Formation. *Modified from the Geologic Map of Pennsylvania (1960).*

STRATIGRAPHY

HISTORICAL BACKGROUND OF UPPER DEVONIAN STRATIGRAPHY

In the last 125 years, expansion of thought concerning the Devonian Catskill delta has in many instances set the precedent for stratigraphic practice in North America. For this reason a brief resumé of the history of stratigraphy for those rocks is presented here.

The development of the science of stratigraphy in the Devonian rocks of the Appalachians began in 1838 with the Second Annual Report of the Pennsylvania Geologic Survey. H. D. Rogers, the first State Geologist, applied a strictly lithologic subdivision utilizing Roman numerals for designation. In the Formal Report of the First Pennsylvania Survey, Rogers (1858) unsuccessfully suggested an elegant classification based on periods of the "geologic day." The more popular binomial method of designation by geographic name was introduced in New York, by James Hall (1839, 1840) and other workers (Vanuxem, 1839, 1840, 1842; Emmons, 1846). The several stratigraphic units which the New York workers designated in the first subdivision of the Upper Devonian section were based partly on lithologic, partly on paleontologic distinctions. These units have been extended throughout the central Appalachians.

Renewed stratigraphic studies in New York by Clarke (1885, 1898, 1904; Clarke and Luther 1904) and H. S. Williams (1884, 1887, 1906) utilized the terminology of Hall and Vanuxem but with some revision because of an increasingly strong emphasis on biostratigraphic subdivision. At about the same time publications of the Second Pennsylvania Survey, summarized by Lesley (1892), endorsed the New York names as synonyms for the earlier numerical nomenclature of Rogers.

For mapping projects initiated in 1900, the Maryland Geological Survey (Prosser and Swartz, 1913) subdivided the Upper Devonian on the basis of the paleontologic differences established in New York, but used several new names. The West Virginia Geological Survey utilized the New York nomenclature in early mapping projects from 1906 to 1924. Butts (1906, 1918, 1940, 1945) designated units in the Upper Devonian exposed along the Allegheny Front in Pennsylvania on a lithologic basis but retained some of the paleontologic boundaries already in widespread use.

An attempt by Caster (1934) to distinguish between rock-stratigraphic units and biostratigraphic units in the Upper Devonian was the academic foundation for the modern approach to stratigraphy, but his ideas were not yet fully absorbed when the older principles were reapplied in new work. Chadwick (1935a, 1935b) substantially revised the New York stratigraphy

on the basis of faunal differentiation. At this time, utilization of biostratigraphic units as "members," "formations," and even "groups" reached its fullest development. The gross New York faunal subdivisions of the Upper Devonian were re-endorsed in Pennsylvania by Willard (1934, 1935b, 1939). Willard also made additions to the lithic nomenclature established by Butts and applied it throughout the state. In West Virginia, Woodward (1943) partially retained the New York names and, like Willard, extended the rock-stratigraphic units of Butts. In their southernmost outcrops in Virginia some of these units retain the names given by Butts.

The most recent stratigraphic work on the Devonian of the Catskill delta has tended to emphasize rock units. In New York the work of Pepper, deWitt, and Colton (1956), Colton and deWitt (1958), Sutton (1960, 1962, 1963), deWitt and Colton (1959), and Fletcher (1963) has contributed substantially to the methodology of lithostratigraphy. The Atlas Reports of the Pennsylvania Geologic Survey (Miller, 1961; Conlin and Hoskins, 1962), although not detailed stratigraphic studies, have utilized the lithologically defined units set up by Butts and Willard. Frakes (1963) revised the terminology of Willard to conform with the Code of Stratigraphic Nomenclature of the American Commission on Stratigraphic Nomenclature (1961).

In the course of these many investigations, it was gradually realized that the clastic Devonian section could be divided into an upper group of red strata which occurred at higher stratigraphic levels toward the northwest, and a lower nonred sequence containing marine fossils. This succession was interpreted by Barrell (1913) as a vast deltaic complex which built northwestwardly through time. Most subsequent investigations provide support for this conclusion. The regressive nature of the succession, indicated by the shallow water aspect of the younger beds, is the basis for these early paleogeographic conclusions.

STRATIGRAPHY OF THE FORT LITTLETON FORMATION

The history of development of stratigraphic nomenclature in the Devonian of the Catskill delta reveals that confusion originated from two sources. First, early stratigraphers attempted to refer their widely separate and disparate sections to the one which was first studied. Second, the criteria utilized for recognition of units varied. As a result, rock-stratigraphic and biostratigraphic units, as they are known today, were interchanged.

Such pioneer work in stratigraphy laid the foundations for modern efforts to standardize procedure, as exemplified by the Code of Stratigraphic Nomenclature of the American Commission on Stratigraphic Nomenclature (1961). Usage outlined in the Code of the American Commission is followed in this study.

The Fort Littleton Formation as defined by Willard (1935b, p. 1199) included in ascending order: 1) Harrell Member; 2) Brallier Member; 3) Losh Run Member; 4) Trimmers Rock Member; and 5) Parkhead Member.

The Harrell Member of the Fort Littleton Formation (Figure 3) consists of fossiliferous medium-gray to dark-gray shale and usually measures in excess of two hundred feet thick. The Harrell is widely distributed in Pennsylvania and in some sections lies on the Burket Member of the Rush Formation. In many areas, however, the Harrell is interbedded with and inseparable from the Burket. Most commonly, the Harrell, together with the Rush Formation and the Frame or Sherman Ridge Member of the Mahantango Formation, occupies topographically low ground adjacent to the high ridge of the Trimmers Rock. For this reason the Harrell is seldom extensively exposed but is locally mappable.

The Brallier Member of the Fort Littleton Formation is described as a pale-greenish-gray shale above the Harrell (Butts, 1945, p. 11), but the unit is better characterized as siltstone in extremely regular beds with only subordinate shale. The Brallier exceeds 500 feet in thickness along the Allegheny Front but occurs only as interbeds through the Trimmers Rock Member in central Pennsylvania and is absent in the eastern part of the state.

The Losh Run Member of the Fort Littleton Formation was designated by Willard (1935b, p. 1206) from exposures in Perry County. Abandonment of the name (Frakes, 1963, p. 186; Dyson, 1963) has been suggested because the Losh Run is partially defined by its fossil content and therefore cannot be considered a rock-stratigraphic unit.

The Trimmers Rock Member of the Fort Littleton Formation is the principal subject of this study and is discussed at length in the next section. The Trimmers Rock, which constitutes the bulk of the Fort Littleton, usually lies above the Harrell or the Brallier Member and below the red beds of the Catskill Formation or the greenish sandstones of the Delaware River Flags. The Trimmers Rock was expanded (Frakes, 1963, p. 187) to include similar strata previously termed Losh Run and Parkhead Members of the Fort Littleton Formation and to include the Chemung Formation or Group.* In all exposures studied the Trimmers Rock is the highest member of the Fort Littleton Formation.

EDITOR'S NOTE

* The Pennsylvania Geological Survey does not extend the name Trimmers Rock west to those areas where "Chemung" has been previously mapped. While the name "Chemung" is inadequate for these areas, the Survey feels that locally derived names are more appropriate for these rocks. The Survey also does not use the name Trimmers Rock for "Chemung" in those areas because mapping has not yet demonstrated the physical continuation of Trimmers Rock into the "Chemung." To call the "Chemung" of those areas "Trimmers Rock" may obscure additional complexities of stratigraphy and facies changes that only appear after detailed areal mapping. Additionally, Willard (1939) shows that the Brallier of these areas is correlative of the Trimmers Rock rather than the "Chemung."

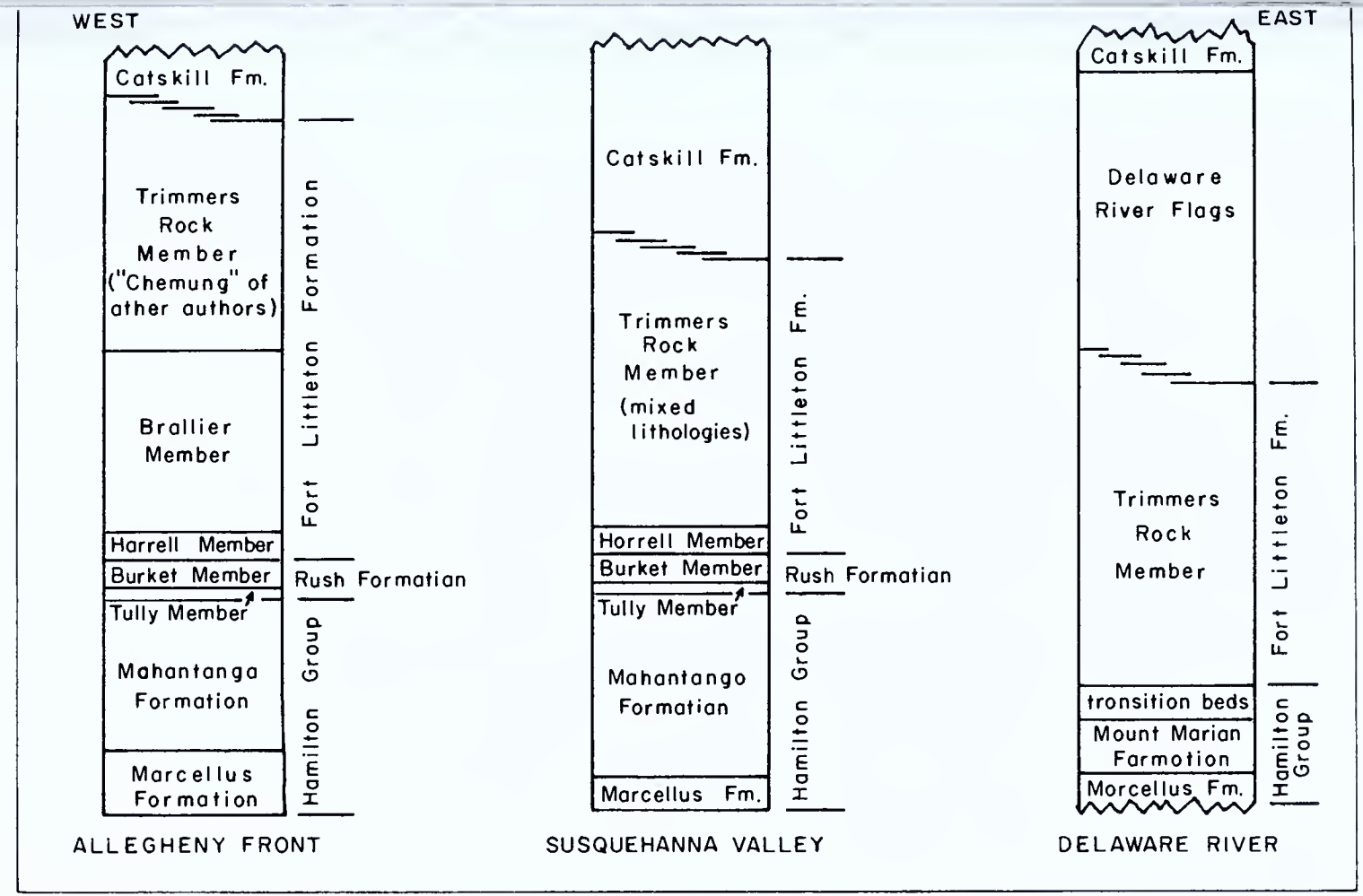

FIGURE 3. Generalized Middle and Upper Devonian sections in Pennsylvania. (*Not to scale.*)

The Parkhead Member of the Jennings Formation of Maryland was originally distinguished both lithologically and faunally (Stose and Swartz, 1912, p. 12). Willard (1935b, p. 1199–1200) extended the unit to Pennsylvania as the Parkhead Sandstone Member of the Fort Littleton Formation. Because there is no lithologic basis for this correlation and criteria for recognition are strictly faunal, Frakes (1963, p. 186) pointed out that the Parkhead has no value as a rock-stratigraphic unit in Pennsylvania. Hoskins (1963, p. 203) concurs in this.

The members of the Fort Littleton Formation recognized in the region of the present study are the Harrell, Brallier, and Trimmers Rock.*

STRATIGRAPHY OF THE TRIMMERS ROCK MEMBER

Definition

The Trimmers Rock Member of the Fort Littleton Formation was named by Willard (1935b, p. 1200–1206) from exposures in a prominent hill on the south bank of the Juniata River east of Newport, Perry County. A type section was not described, but the strata exposed in the railroad cut at Trimmers Rock display the lithologic characteristics used to distinguish the unit throughout the state. The section at Trimmers Rock is incomplete, contains strata of Brallier lithology, and in addition is faulted (see detailed map in Dyson, 1963). Continued use of the name is recommended in spite of these drawbacks because the term has already been widely accepted and applied. The Trimmers Rock is a mappable and well-defined unit in the Juniata and Susquehanna valleys and to the east. Introduction of a new term would only serve to create confusion.

The Trimmers Rock was separated from the overlying Chemung Formation by Willard (1935b, p. 1201) on the basis of the lowest occurrence of "*Spirifer*" *disjunctus*. In the description, Willard noted that this contact is not marked by lithologic change (p. 1201). Similarly, the upper contact of the Trimmers Rock with the intermittently present Parkhead Member was defined by the occurrence of the Parkhead fauna (Willard, 1935b, p.

EDITOR'S NOTE

* After this study was completed, additional field data obtained by members of the Pennsylvania Geologieal Survey resulted in the modifieation of the formal names applied to these roeks. The names Fort Littleton and Rush have been abandoned by the Pennsylvania Geologieal Survey (Hoskins, 1963, p. 200–203). The Trimmers Roek, Brallier and Harrell have been raised to formational status. The Burket has been reinstated as a member of the Harrell Formation following the original designation of Butts (1918). The Pennsylvania Geologieal Survey for the present time includes the Tully as the basal member of the Harrell.

The modification of the formal names has largely resulted from the detailed mapping of these units in the area of the Susquehanna and Juniata Rivers.

1199–1200). Because part of the Chemung and the Parkhead Member are lithologically inseparable from the Trimmers Rock, Frakes (1963, p. 187) extended the Trimmers Rock upward to include all rocks below the Catskill which had previously been designated Chemung or Parkhead. The terms Chemung Formation or Group and Parkhead Member or Sandstone are perhaps of some value in adjacent states when used to refer to lithologically defined units.

Lithologically the Trimmers Rock is composed of gray, green, and brown shale, siltstone, sandstone, and minor conglomerate. More precise descriptions of lithologies are given in the section under that heading. Strata having these characteristics and traceable to the type locality are herein considered as Trimmers Rock.

In the region of the type locality, siltstone beds of Brallier lithology are abundantly present in the Trimmers Rock; the type Trimmers Rock is therefore not ideally separated from the Brallier. In this report the body of mixed lithology is termed Trimmers Rock and the Brallier is not recognized.

Distribution

The Trimmers Rock Member of the Fort Littleton Formation is a continuous unit in the surface exposures of Devonian strata in Pennsylvania, and rocks of nearly identical lithology are traceable across the state boundaries into New York, Maryland, and West Virginia. Similar strata are known in considerable detail in the subsurface of western Pennsylvania but are not included as a part of this study.

The Trimmers Rock of eastern Pennsylvania is traceable into similar beds in southeastern New York which have been designated as Mount Marion Formation and the overlying Ashokan Flags (Grabau, 1917, p. 954; Chadwick, 1944, p. 104–112; Fink and Schuberth, 1962). A comparison of lithologic features strongly suggests that the Trimmers Rock is a lithic equivalent of the middle and upper Mount Marion (Frakes, 1963, p. 197). The Ashokan appears to be a homotaxial lithic equivalent of the Delaware River Flags, which overlie the Trimmers Rock in eastern Pennsylvania.

Dennison (1963) has summarized Upper Devonian stratigraphic variation along the Allegheny Front in Maryland and West Virginia. In Maryland, possible lithologic counterparts of the Trimmers Rock are designated as part of both the Chemung Sandstone and the Parkhead Sandstone Members of the Jennings Formation whereas these same strata are included as portions of both the Chemung Formation and the Brallier Shale in West Virginia. As defined in both Maryland and West Virginia, the Chemung actually represents a *biostratigraphic* unit since it includes all rocks above the Brallier which contain marine fossils. Moreover, since in many cases marine fossils occur well above the lowest red beds, the Chemung in these states is only in part lithologically the same as the Trimmers Rock.

Relationships to Other Rock Units

The Middle and Upper Devonian strata of the Catskill delta represent a regressive sequence in which deep-water black shales are overlain by progressively shallower water deposits culminating in the red beds of the Catskill Formation. On a regional scale, therefore, black shales are lateral equivalents of red beds (Willard, 1939).

In the past, delineation of the base of the Trimmers Rock has not proved to be a source of great disagreement among workers, except in places where siltstone beds are widely dispersed in shale at the base. The practice has been to term such dominantly shale units Brallier Member (Willard, 1935b, p. 1207), because the Brallier was originally defined as a shale containing few siltstone beds (Butts, 1918, p. 531). Butts added (1918, p. 523–524; 1945, p. 11) that the "pale greenish-gray" color of the Brallier is in contrast with the "dove-gray" color of the Harrell.

Study of rocks termed Brallier at Girtys Notch (Willard, 1939) and Huntingdon (Butts, 1945) reveals that color is not a distinctive feature and that the unit is not predominantly shale but instead is characterized by distinctive regularly bedded siltstone and subordinate shale. In the central area of the present study siltstones of Brallier lithology are interbedded through the Trimmers Rock which lies in sharp contact on gray shales of the Harrell. Typical Brallier siltstones occurring as interbeds in the Trimmers Rock are designated Type II beds in this region, and the Brallier is not recognized as a unit (Figure 3). Southward from about the mid-latitude of Perry County and eastward from Bowmanstown in Carbon County, Brallier siltstones are not observed in the sections measured.

At Port Jervis, New York, strata of Trimmers Rock lithology are transitional downward into gray, poorly bedded siltstones typical of the Mount Marion Formation of Chadwick (1944). These Trimmers Rock beds are mapped as Mount Marion Formation by Fink and Schuberth (1962). These relationships are shown in Figure 3. In this section, the Mount Marion underlies strata here termed Trimmers Rock and the Harrell is not recognized. The lower portion of the Trimmers Rock at Port Jervis wedges out to the west and is in part laterally equivalent to the Harrell Shale (Plate 1).

Strata of Trimmers Rock lithology are overlain by red beds of the Catskill Formation throughout the state except in eastern Pennsylvania where green sandstone of the Delaware River Flags intervenes between the Trimmers Rock and the Catskill (Figure 3).

The top of the Trimmers Rock is placed at the base of the lowest occurrence of reddish-brown colors in the range 5 R 4/2 to 10 R 4/2 (Goddard and others, 1951). This mappable horizon is definitive for the basal contact of the Catskill Formation (see Hoskins and others, 1963, p. 161–162). At all sections studied the lowest Catskill red beds consist of hackly weathering

shale; Catskill strata between red shales are composed of green, brown, and gray siltstone, sandstone, and shale greatly similar to their counterparts within the Trimmers Rock (Frakes, 1961, p. 122–123). Exact relationships of the Catskill to the Trimmers Rock are not presently known although Plate 1 shows that the two units occupy positions of partial lateral equivalence. The absence of angularity at the contact and similarity of some strata on either side further suggest that red shales are laterally gradational into gray shales. Possibly this suggestion can be verified by detailed description and lithic correlation of the lower Catskill rocks with upper Trimmers Rock strata on a regional basis.

The base of the Delaware River Flags is placed where greenish flagstone with minor amounts of intercalated shale becomes dominant in the section. At Millrift, in the Port Jervis section, the contact with the underlying Trimmers Rock is apparently sharp although only the basal 10 feet of flagstone is exposed. A similar relationship is seen in the Hess well, 9 miles north of Port Jervis, where sandstones with little shale lie in sharp contact on siltstones and shales of the Trimmers Rock. In surface sections and wells farther west, however, the Delaware River Flags are transitional downward into the Trimmers Rock. At Winona Falls transition strata are considered to be 144 feet thick. Transitional relationships between these two units are also exposed along Routes 191 and 196 south of the village of Analomink, Monroe County.

In those areas where the Delaware River Flags lie above the Trimmers Rock, as at Port Jervis, the lowest red shales of the Catskill are found in a considerably higher position than normal. In effect, the Delaware River Flags occupy an interval between the Trimmers Rock and the Catskill Formation, and where the flagstones are not present the Catskill lies directly on the Trimmers Rock. The question arises whether the Delaware River Flags are lateral equivalents of the Trimmers Rock or the Catskill or both. The existence of a Trimmers Rock-Delaware River transition zone and the fact that the base of the Delaware River Flags appears to be stratigraphically lower at Port Jervis than at Analomink suggest strongly that the Delaware River Flags are eastern equivalents of the upper Trimmers Rock. Quite possibly, the Delaware River Flags are also eastern equivalents of the lower Catskill.

Age

The age of all rocks in the Catskill delta has until recently been considered to be Middle and Late Devonian. The only known exception to this classification are the youngest Catskill rocks of the Susquehanna Valley region in which an Early Mississippian flora has recently been discovered (Trexler and others, 1961).

In the central region of the present study the Trimmers Rock is considered to be Late Devonian in age because these rocks lie several thousand feet below the Mississippian flora and because they are also well above the Tully Limestone, which is considered the base of the Upper Devonian section (Willard, 1939, p. 207). In eastern Pennsylvania, where the Trimmers Rock occupies positions below limy shales interpreted as Tully equivalents, the lower portions of the unit are considered Middle Devonian in age. The fact that the lower Trimmers Rock is a lateral equivalent of the upper portion of the Mount Marion Formation of Middle Devonian age supports this contention.

Because this study is concentrated on the lithic rather than the biologic features of the Trimmers Rock, no attempt is made to divide the section into stages or to establish range or assemblage zones.

Thickness

Thickness variation of the Trimmers Rock is shown in the isopach map, Figure 4. Thicknesses utilized in constructing this map are obtained from the data of the measured sections and represent thickness of strata of Trimmers Rock and Brallier lithology below the Catskill or Delaware River Flags and above the correlation datum at the top of Shale Unit 2 (Plate 1).

Data utilized from the wells in northeastern Pennsylvania represent isocores rather than isopachs. However, as judged from regional structure dips are relatively slight in these wells, and, although the thick section in the Knorr well may be a reflection of this inaccuracy, thicknesses given are in most cases approximately the same as thickness perpendicular to bedding.

Perhaps the most meaningful method of interpreting the isopach map is to consider that the isopach lines reprcsent lines of equal thickness of the arenaceous section above Shale Unit 2 and below the Catskill. Viewed in this manner the map shows thickness variation of a lithologic body which is bounded above by interfingering relationships. Accordingly, the meaning of thickness variation for the Trimmers Rock is not as clear as for stratigraphic units bounded by planar contacts. The generalization can be made, however, that areas of great thickness represent areas where the base of the overlying Catskill occurs relatively high in the section; in areas of less thickness the Catskill occupies rclatively low positions.

From Plate 1 and Figure 4, some generalizations may be made about distribution of the basal Catskill in space. On the isopach map the interval measured is smallest near the eastern and southern outcrop margin, and in the stratigraphic diagram, the basal Catskill red bed gcnerally occurs lowest along the extreme southcastern belt of exposure. The basal red bed occurs at progressively higher levels toward the northwest. Isopach lines are widely spaced and irregular in the central region of this study, the area of maximum interbedding of Trimmers Rock and Brallier lithologies.

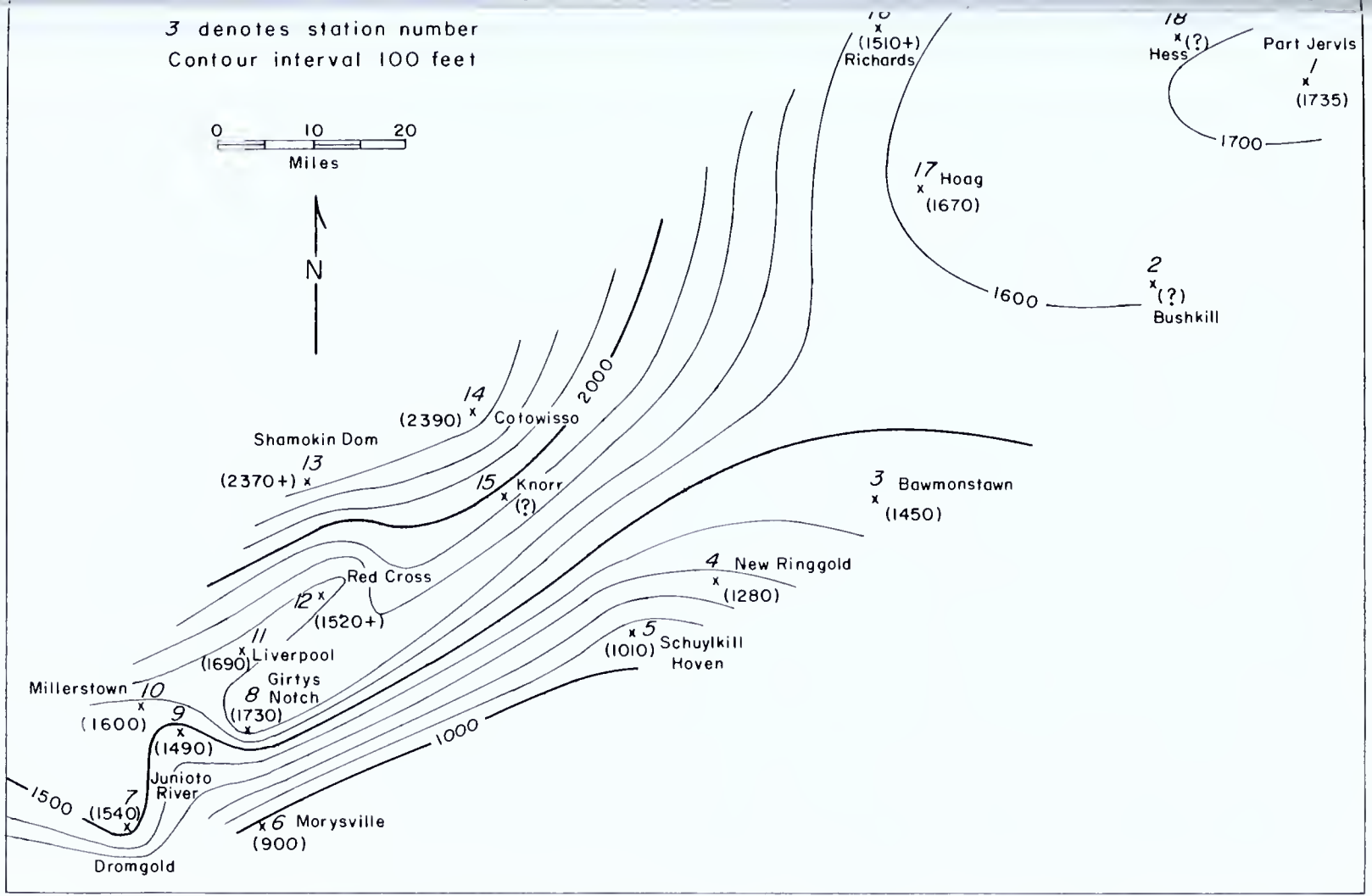

FIGURE 4. Isopach map of the Trimmers Rock Member of the Fort Littleton Formation.

Informal Units

Lithic variation in the Trimmers Rock is monotonously repetitious and because of this characteristic very little was known prior to this study about the distribution of rock-types or other features within the unit. After the sections were described in detail the Trimmers Rock was divided into informal stratigraphic units which are recognizable over wide areas. Using this subdivision variation of such features as rock-type, bed thickness, color, and type and orientation of sedimentary structures may be discussed on a more precisely defined stratigraphic framework than they could for the entire Trimmers Rock.

The work of Sutton (1960) on the Upper Devonian of New York demonstrates the practicability of studying shale bodies to accomplish breakdown of a thick section into workable units. For the purposes of this study, lithic correlation utilizing shales proved to be an entirely satisfactory procedure. The Trimmers Rock is divided by nine shale bodies into ten units consisting dominantly of siltstone and sandstone (Plate I).

Matching of units between sections illustrated in Plate I was begun by establishing a datum on the top of Shale Unit 2. The only reasonable alternative to using this position as a base is to use the top of the Tully Limestone; the latter horizon is considered inadequate because the Tully is not a good lithic unit and moreover, is frequently covered in the region of this study. However, parallelism is good between the top of Shale Unit 2 and the intermittently present Tully (Plate I). Homotaxial relationships were used to fix this base in the eastern sections where the Trimmers Rock occupies relatively low stratigraphic positions. Correlation of shale bodies higher in the section is based on homotaxis and shale character. The latter criterion was used sparingly because such characteristics as siltiness and degree of development of fissility could not be evaluated completely and objectively. By these methods shale units are defined, their position in the section is determined, and rock-bodies consisting of more abundant arenaceous strata are delineated between each set of two bounding shale units.

The designation of these units as Shale Unit 3 or Siltstone Unit 6 is informal in the terminology recommended in the Code of Stratigraphic Nomenclature (1961, Art. 4f). Shale and siltstone units are lithologically defined, practical units for use in stratigraphic study and are thus established in agreement with Article 4a of the Code. The lowest siltstone body above the Mount Marion Formation is designated Siltstone Unit 1; the next-higher shale body is termed Shale Unit 1. Succeeding units are numbered consecutively, and bifurcating units carry supplementary letter designations. Siltstone Unit 5b is differentiated by consisting dominantly of subgraywacke and conglomeratic sandstone.

Thickness variation of siltstone units is shown in Figures 5-13. These isopach maps are constructed from the data of the measured sections and the less reliable information of the well-sample descriptions.

Orientation of sole marks and ripple marks are summarized on the isopach maps. Discussion of the paleogeographic significance of isopachs and paleocurrent indicators is given in the section on paleogeography.

The most obvious feature of the isopach maps is an elongate area of maximum thickness trending roughly east-northeast. This characteristic is present in Siltstone Unit 2 (Figure 6), Unit 5 (Figure 9), Unit 6 (Figure 10), and Unit 7 (Figure 11). The area of maximum thickness shifts northwest from Unit 1 through Unit 9.

Areas of great thickness are concentrated along the southern margin of Devonian surface exposures. These for the most part display isopachs convex toward the northwest. The most prominent of these areas centers in the region of the Bush Kill and Port Jervis sections for Unit 1 (Figure 5) and Unit 3 (Figure 7). Another centers at New Ringgold for Unit 2 (Figure 6) and Unit 5 (Figure 9).

Southward thinning is suggested in Units 6 through 9 (Figures 10-13). However, this thinning is a function of interfingering relations with the Catskill Formation. As shown on the figures and Plate 1, the zero isopach represents complete lateral replacement of these units of the Trimmers Rock by the Catskill Formation.

It is concluded from these studies that individual siltstone units in the Trimmers Rock *thicken* toward the south and southeast whereas the entire Trimmers Rock, because of interfingering with or lateral replacement by the Catskill Formation, *thins* in the same directions.

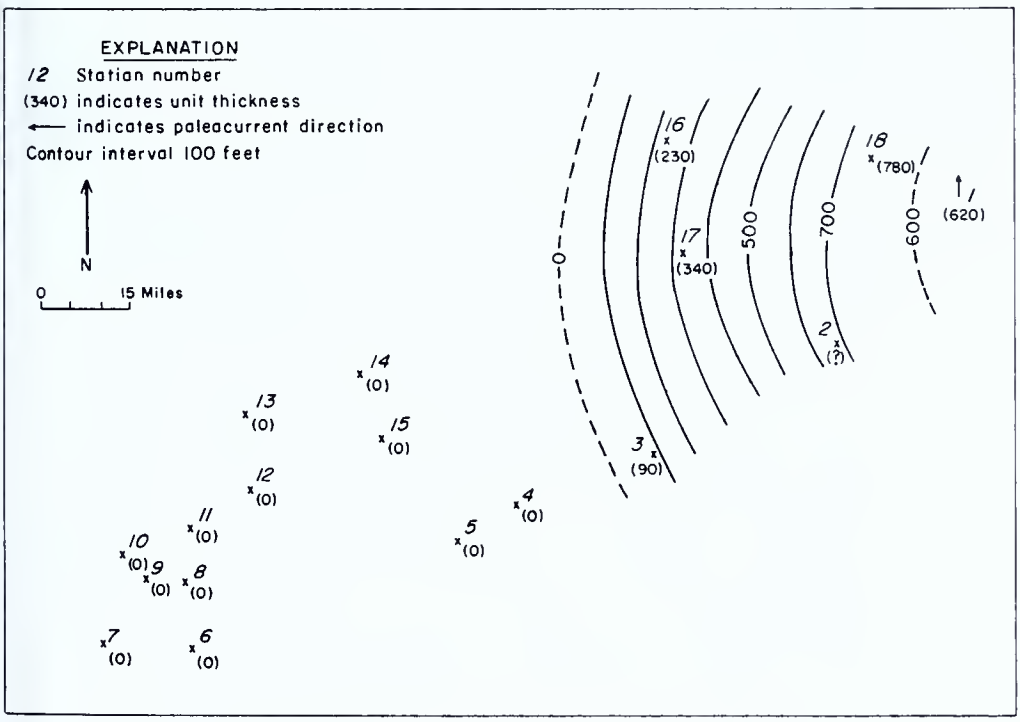

FIGURE 5. Isopach and paleocurrent map of Siltstone Unit 1.

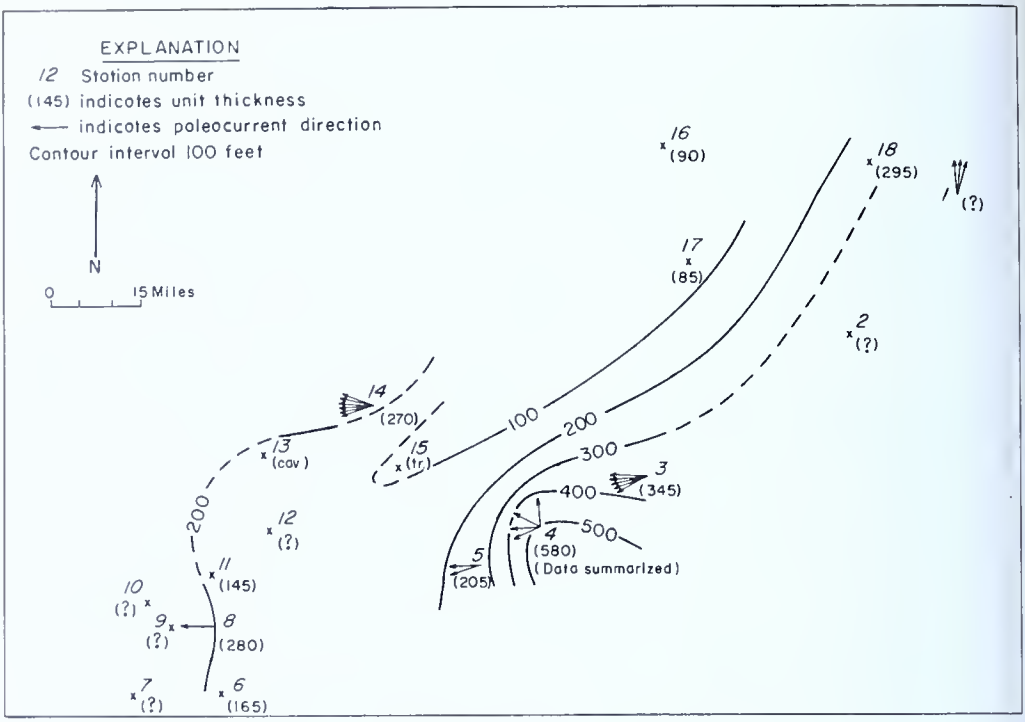

FIGURE 6. Isopach and paleocurrent map of Siltstone Unit 2.

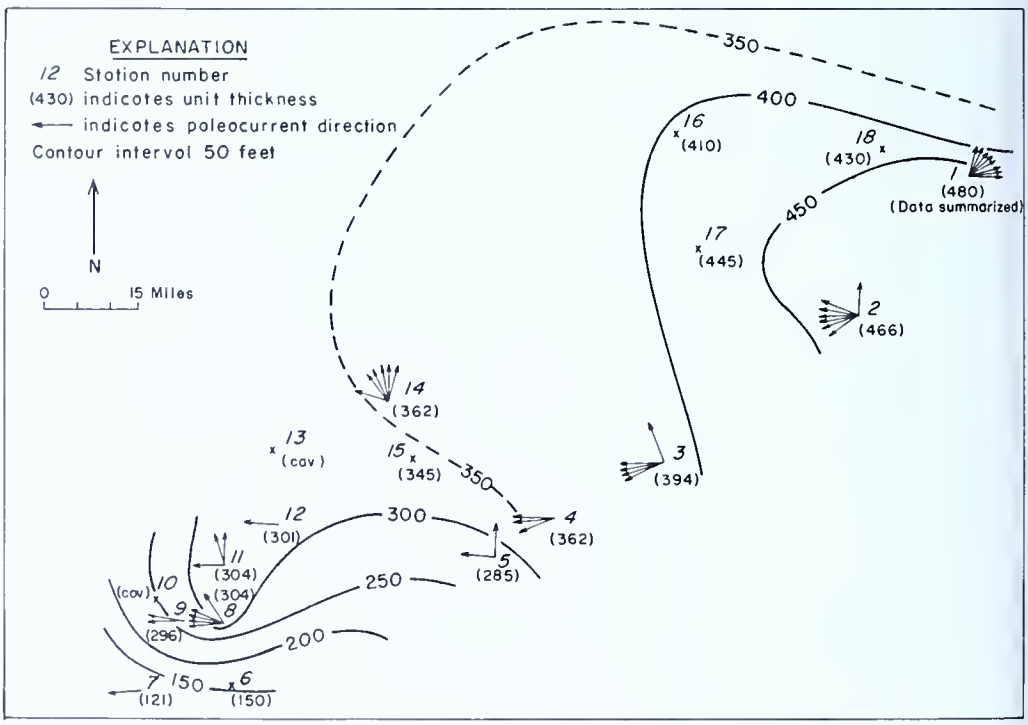

FIGURE 7. Isopach and paleocurrent map of Siltstone Unit 3.

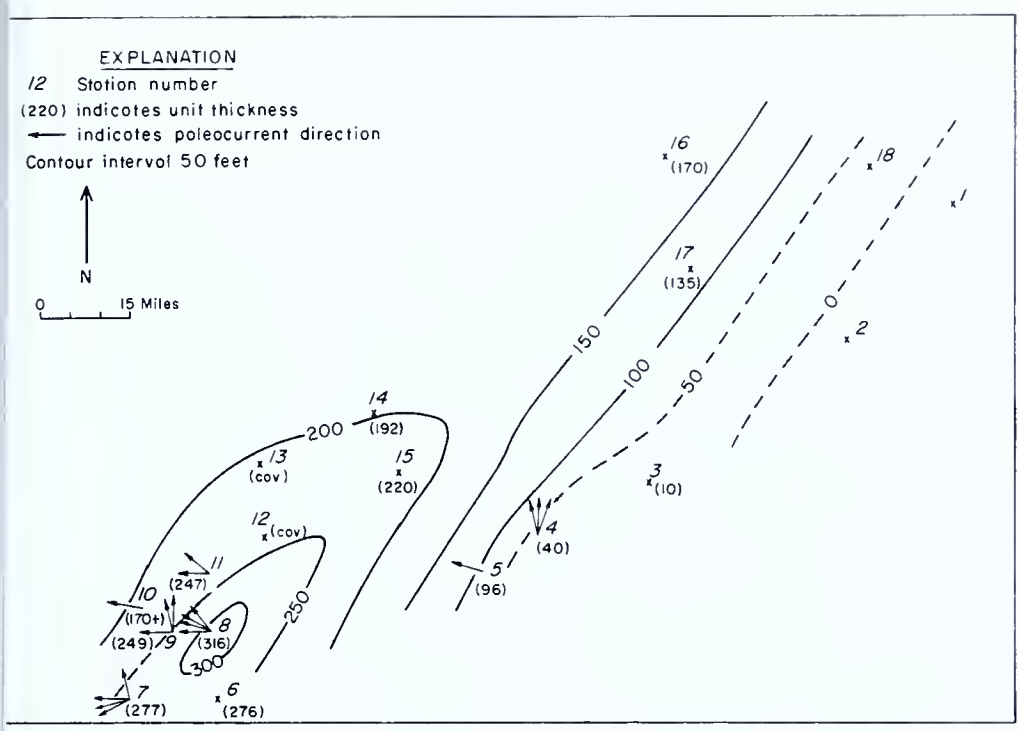

FIGURE 8. Isopach and paleocurrent map of Siltstone Unit 4.

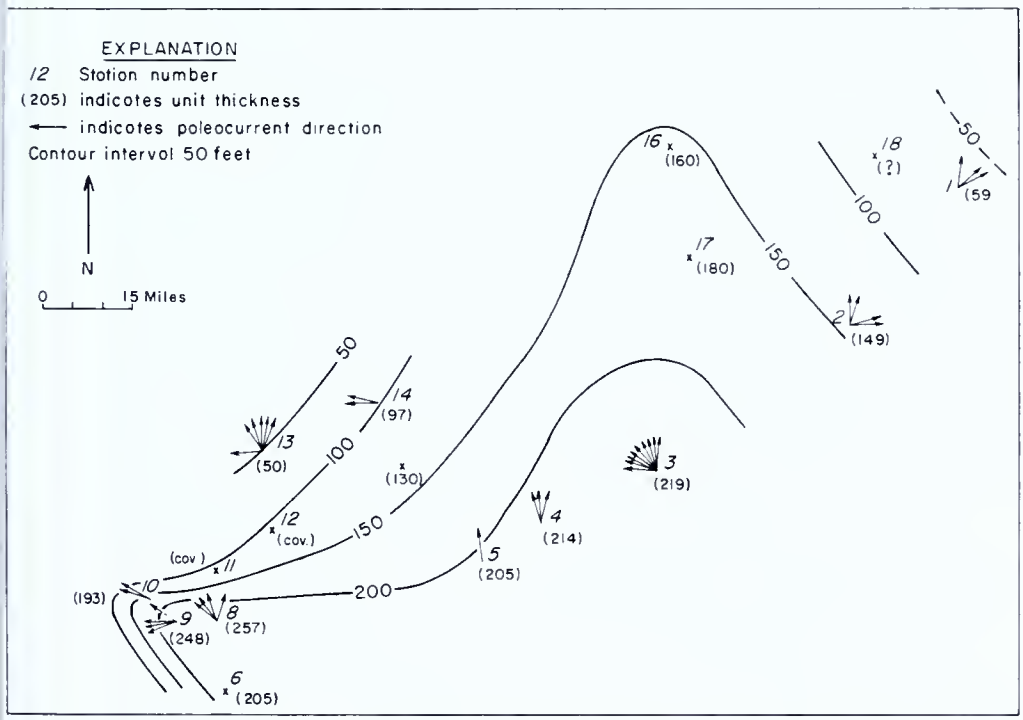

FIGURE 9. Isopach and paleocurrent map of Siltstone Unit 5.

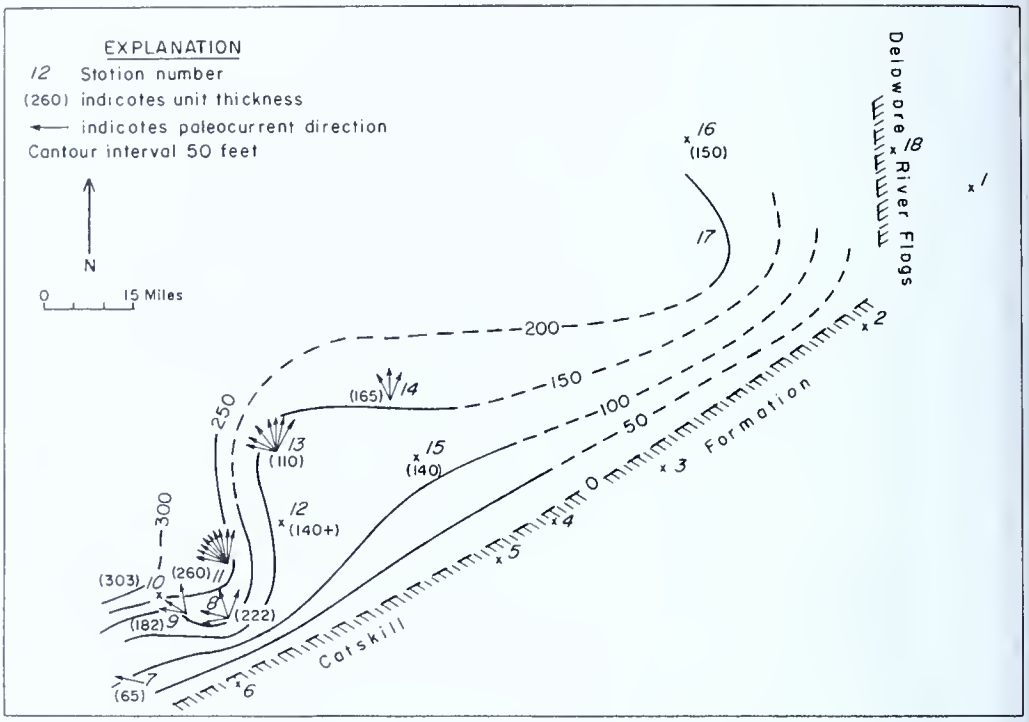

FIGURE 10. Isopach ond poleocurrent mop of Siltstone Unit 6.

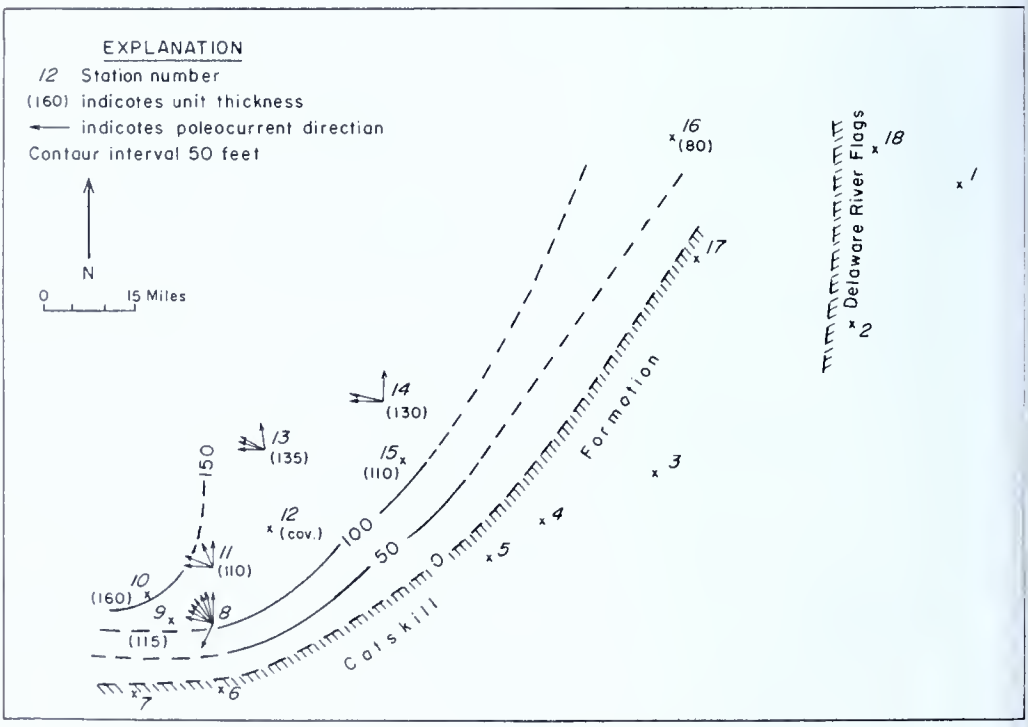

FIGURE 11. Isopach and paleocurrent map of Siltstone Unit 7.

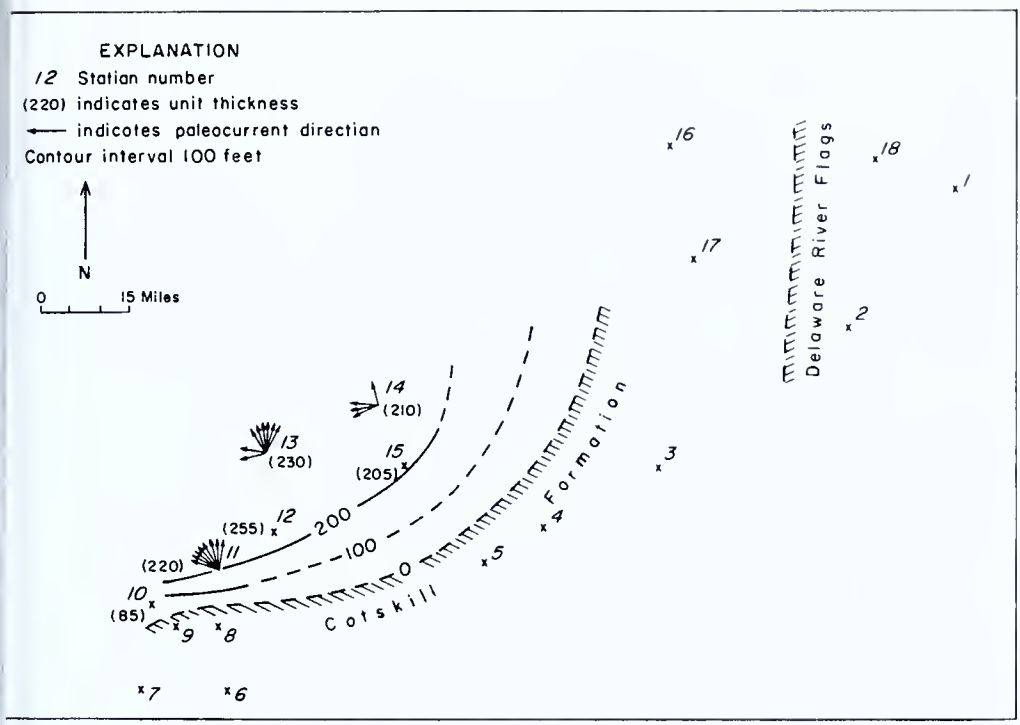

FIGURE 12. Isopach and paleacurrent map of Siltstone Unit 8.

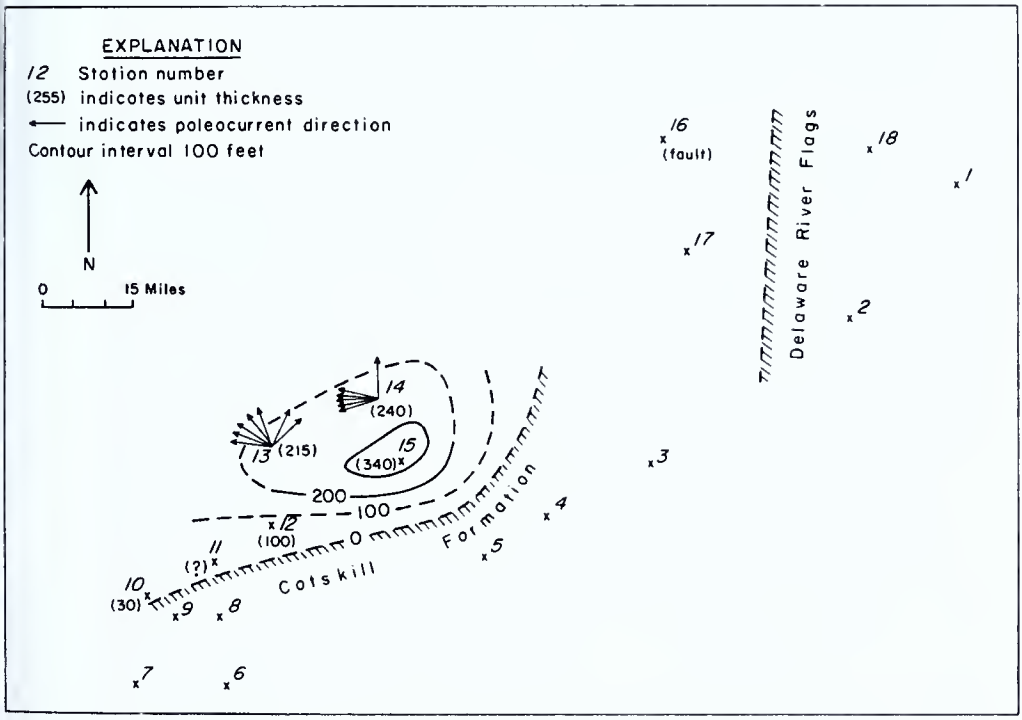

FIGURE 13. Isopach and paleacurrent map of Siltstone Unit 9.

METHODS

Lithic Description

The Trimmers Rock Member of the Fort Littleton Formation consists dominantly of alternating graywackes and shales, attains total thicknesses in excess of 3500 feet, and is exposed over several thousand square miles in Pennsylvania. The detail obtainable in a regional study is consequently largely controlled by the time available for study. Extremely detailed work involving measurement in inches was not warranted by the time factor. On the other hand, detailed mapping and preliminary examination of sections of the Trimmers Rock disclosed that not enough information could be obtained by measuring sections at the scale of hundreds of feet. The problem was to find some method of rock description that could be properly applied within a reasonable time.

A nearly complete section exposed along Routes 22 and 322 about 2 miles north of Amity Hall in Perry County was first examined in an effort to determine the physical features of the Trimmers Rock and their variation. In this work it was discovered that the obvious lithologic characteristics of the Trimmers Rock vary in such a way that the section can be described by units of intermediate thickness which yield a considerable amount of information in a relatively short observation-time. Units average between 5 and 10 feet thick for the sections described by this method. These measurement-units are separate and distinct from the informal rock-stratigraphic units delineated on Plate I.

Breaks in lithologic regularity define the measurement-unit; such breaks are more or less apparent in the field depending on such factors as extent of differential weathering and outcrop-size, in addition to variation of the lithologic features themselves. Observed breaks between units of differing lithologic character are based on variation of the following lithic features, which are listed in approximate order of usefulness:

1. Percentages of the principal rock-types.
2. Bed thickness of siltstones and sandstones.
3. Color for all textural types.
4. Loading or movement criteria.
5. Abundance of fossil-fragment layers.
6. Abundance of cross-stratification.
7. Character of fissility in shale.
8. Grain size in sandstone.
9. Conglomeratic character.

For most measurement-units, the percentage of the whole occupied by graywacke and the thickness of graywacke beds are the most obvious variables. Grain-size variability is difficult to detect because of the textural characteristics of the graywackes and is valuable only in cases of extreme

variation. The color designations are useful to a certain extent, and in some cases they change in the midst of an otherwise homogeneous section. In such examples color change is utilized to subdivide the section. Accumulations of depositionally loaded structures and debris showing evidence of lateral movement are designated as measurable units by virtue of their distinctive character. Graywackes containing layers of fossil fragments or cross-stratification are separated from adjacent barren units. The relative abundance of these features is noted and sometimes serves as the basis for separation of units. In thick shale sequences, the variable character of fissility allows separation. Locally the conglomeratic texture of some sandstones makes them distinct from adjacent strata.

For the section descriptions the scale of measurement was set on a practical basis. Beds less than 6 inches thick were not directly measured, and all units were measured to the nearest ½ foot. Units thinner than 5 feet were split out only if their boundaries are distinctly marked by change in lithologic character. All shale units greater than 3 feet thick were noted as separate units.

Once the decision was made on the position of the boundaries for any unit, the thickness of the unit was determined by measurement perpendicular to bedding from top to base. All exposed strata were measured within 5 feet of the base of the outcrop except in irregularly exposed sections, in which case change of location is noted in Appendix A. Covered intervals were traversed with steel tape and Brunton compass and thicknesses were determined from these data by the methods of descriptive geometry. In one case, unit 86 at Port Jervis, this method was impractical because of long distances involved. In this example, covered thickness was determined by plotting locations and attitudes on the 7½-minute topographic map and solving by descriptive geometry.

Error of Estimation

Relative abundance of the major rock types in the Trimmers Rock is of value in construction of isolith maps as well as in lithologic correlation. Abundance of rock types was obtained by estimation methods in this study. It is necessary to evaluate the method of estimation before these data can be utilized in isolith maps.

A 70-foot section in Siltstone Unit 4 at Marysville was described by a series of estimates at the beginning of field work and again at the conclusion. This was done by the same procedure used throughout the study, that is, by 1) establishing a measurement unit of rocks on the basis of its contrast with adjacent strata, 2) estimating amounts of each rock type present, and 3) measuring the thickness of the unit. The same 70 feet was then measured to ½-inch accuracy. The boundaries of each measurement unit are correlated with the detailed measurements in Figure 14.

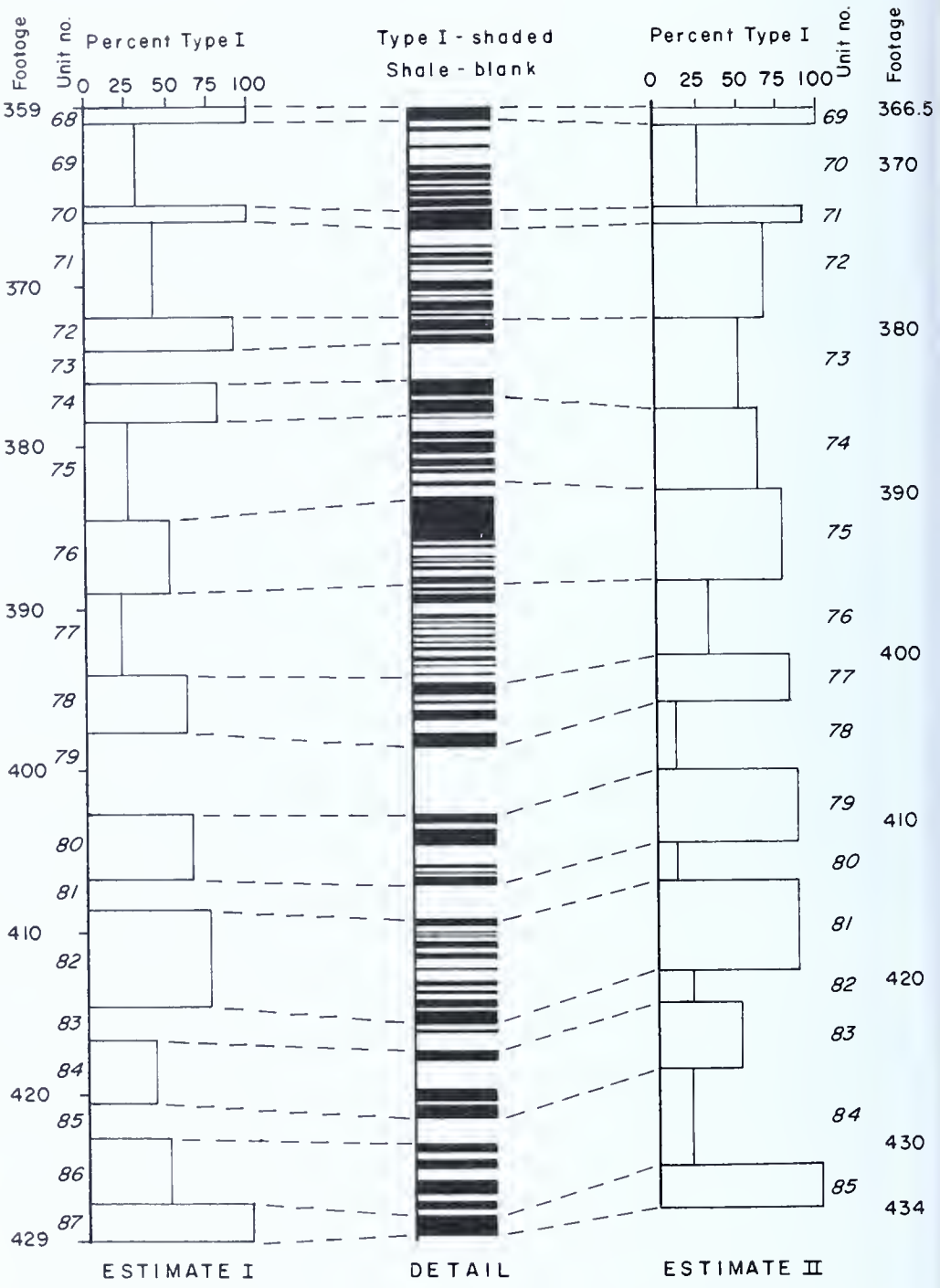

FIGURE 14. Comparison of estimates of beds in measured section with detailed measurement of the same section.

For the purpose of quantitative comparison with the detailed measurements, the total thickness of Type I beds in the 70 feet is calculated from the 20 estimates made during each run, and converted back into percentage of the total thickness. Run 1 yields a total of 42.6% Type I and run 2, 51.5% Type I beds. When compared with the value obtained from the detailed measurement, 47.7% Type I, it is seen that run 1 contains an error of −5.1% and run 2 an error of +3.8%, expressed in terms of the estimated percentages. These data indicate a lack of drift in operator definitions made throughout the study.

To calculate the standard error of estimate, the data obtained during both runs might be used. By using only data from the run with the largest error, determination of the maximum error is assured. Therefore, the 20 estimates of run 1 are employed as follows to calculate the standard error of estimate:

$$S_{XE} = \left[\frac{\Sigma(X - X_E)^2}{N}\right]^{1/2}$$

where X is the percentage of Type I beds in a measurement-unit, as calculated from the detailed measurements; X_E is the estimated percentage of Type I beds in a measurement-unit; and N is the number of measurement-units in the run.

The standard error of estimate derived from these calculations has a value of 10%. This means that the percentage estimates for the measurement units in Appendix A can be considered to be accurate within ± 10%.

Data gathered by this method are utilized to show distribution of rock types in informal rock-stratigraphic units (Figures 51–55). The values which are contoured represent the percentage of the rock type in the stratigraphic unit at the different localities. These values are calculated by determining the total thickness of the rock type from the individual measurement units and expressing this as a percentage of the complete thickness of the stratigraphic unit. Thus, the values are similar to sand-shale ratios and clastic ratios in sequences consisting of two lithologies. Because the Trimmers Rock consists of four major lithologies, three of which span the sand-silt size boundary, construction of maps showing variation in the sand-shale ratio is not practicable. Isolith maps of this study thus show the geographic and stratigraphic variation of a single type of rock rather than a mixture of several types.

The standard error of estimate is assumed to be randomly distributed through the network of observation stations. On this basis, the optimum error of 20% will rarely occur between two adjacent stations, and utilization of 10% contours is justified. For this rare occasion, however, the effect will be to widen or narrow the distance between contours. In interpretation of the maps, the critical feature is the *trend* of the line, which on a regional

scale could only be effected by cumulative error and not significantly by random error. On the other hand the percentage differences indicated by the relative positions of the 20% and 30% contours for example are considered to be reliable because of the nearly complete lack of "noise," represented by small areas of closed contours.

LITHOLOGY

GENERAL STATEMENT

The Trimmers Rock Member of the Fort Littleton Formation is characterized lithologically by shale and intercalated siltstone and sandstone. Shale is dominant in all sections studied. Siltstone is next in order of abundance while sandstone (strictly defined) is not abundant. Three different types of siltstone-sandstone are distinguished on the basis of bedding character. Conglomerate and conglomeratic sandstone are relatively limited in abundance.

SHALE

General

Shale constitutes the bulk of the Timmers Rock Member of the Fort Littleton Formation and is present as a wide variety of types. Shale thicknesses range from a fraction of an inch to several tens of feet. Toward the base of the Trimmers Rock, shale locally increases in abundance, but generally the contact with the underlying Harrell Shale Member is abrupt.

The physiographic expression of shales in the Trimmers Rock is that of a low or eroded area. This characteristic holds true, with local exceptions, for shale units of any thickness. Shale sections in excess of ten feet thick generally serve as the site for intermittent and perennial streams, and are consequently worn low. Thin shale layers or partings between coarser grained layers commonly show as eroded grooves or notches in profile.

Recognition of shale in the field is based on two criteria: 1) most grains not discernible with 10X hand lens; and 2) presence of fissility.

Texture and Composition

Textures of shales in the Trimmers Rock Member of the Fort Littleton Formation were studied in hand samples and in a few thin sections. In de-

scribing outcrops three major types of shale are distinguished on the basis of texture.

The most common type of shale in the Trimmers Rock contains small amounts of scattered silt-sized quartz. Such shales have a dull, nongranular appearance under the hand lens. A second shale type is characterized by a considerable quantity of silt-sized quartz. This type is distinguished by the vitreous luster imparted to the rock by the abundant quartz and is indicated in the measured sections by the notation "silty shale". The rare third type of shale is termed "argillaceous" in Appendix A. Argillaceous shale contains very little quartz in the silt-size classes except within the fossil burrows which contain abundant amounts of this mineral. Generally, argillaceous shales weather light yellowish brown (10 YR 6/6–5 Y 7/6) and yield a clay-rich soil.

The most obvious textural feature of shales in the Trimmers Rock is the presence of both a matrix and a framework fraction. In this regard, shales are textural counterparts of siltstones in the Trimmers Rock, with the exception, of course, that shale is finer grained.

The term "framework fraction", as originally used by Nanz (1954, p. 106-108) and as now commonly utilized, is a textural term applied to the detrital sand-sized material of a sandstone. As used in this paper, framework fraction is extended to include all coarse material in rocks with bimodal size distributions. Extension of the definition is necessary because of the complete textural gradations between sandstones and siltstones and siltstones and silty shales. The prominent fine-grained interstitial aggregate of quartz, muscovite, chlorite, and sericite in Trimmers Rock graywackes is here termed matrix.

Shales of the Trimmers Rock consist of a dominant matrix (60-95%) and a subordinate framework of silt-sized grains. The framework fraction of shales consists principally of quartz. Other framework minerals include detrital ziron, hematite, and feldspar, all not abundant. Euhedral crystals of pyrite, on the order of one micron diameter, are abundant and apparently authigenic.

As noted, most shales of the Trimmers Rock are dominantly matrix and scattered grains, but numerous layers of concentrated silt grains occur. The latter range in thickness from a single lamina of silt grains to units about one inch thick. Discussion here is restricted to laminae (less than 2 mm thick). Laminae are composed almost entirely of silt-sized quartz with subordinate opaque minerals. Quartz grains in laminae average about the same size as quartz grains outside laminae. If laminae are abundant, at least $\frac{1}{2}$ mm thick, and laterally persistent, they are distinguishable in hand specimen, and the rock is termed laminated shale. More commonly, laminae are thin, widely spaced, and discontinuous; such rocks are referred to as silty shale.

Structure

Fissility

Fissility in shales of the Trimmers Rock is variable from unit to unit. In the measured sections (Appendix A) degree of fissility is recorded by number as 1, 2, or 3. Shales of fissility designation 1 display well-developed, or good, fissility. Good fissility is a field term applied to those shales which display abundant, closely spaced, and continuous fissility throughout the outcrop. A large majority of the Trimmers Rock shales have good fissility. Shales of fissility designation 3 possess poor fissility. The term is applied to shale units in which planes of fissility are sporadic and irregular in distribution. Fissility designation 2 applies to fissility which is faily well-developed; this designation is obviously quite subjective and arbitrary.

Combinations of cleavages, joints, and planes of fissility in various stages of development result in distinctive types of shales. Very closely spaced planes of fissility in compact shales with little jointing or cleavage causes weathering to large (1″-9″) sheets. Such shales are termed paper shale. Typically fissile shale thoroughly broken by cleavage disintegrates to prismatic fragments with the longest dimension parallel to fissility and cleavage. Because the long dimension is frequently at least 10 times the magnitude of the other dimensions the fragments resemble rude pencils and the shale is termed pencil shale.

Snowball Structure

Another common feature of the shales of the Trimmers Rock is the concentration of curved splitting surfaces into ellipsoidal cells (Figure 15) here referred to as snowball structure. The external form of snowball structure is apparently caused by mechanical disintegration of fine-grained mudstone containing ellipsoidal "cells" of discontinuous splitting surfaces which appear to spiral inward. At the outer margin, the cell exhibits a variety of terminations, but generally the outermost splitting surface dies out in normally fissile shale. Internally, slightly staggered splitting surfaces gyrate inward and terminate irregularly against a nonfissile core ½″-4″ in diameter. Some cells transect one another but more commonly they lie in ordered rows parallel to bedding. Most cells have an ellipsoidal form, and sections through them therefore display all shapes from nearly perfectly circular to highly eccentric elliptical. The longest dimension of the ellipsoid usually lies very nearly parallel to adjacent bedding planes. Individual snowballs are usually 1′-2′ in diameter; the largest observed in the Trimmers Rock measured 7′6″.

Snowball structure occurs most abundantly in nonsilty shale units having a thickness of more than about one foot. In thick shale sections the structure is common, particularly in the region of sparse outcrops of the Trimmers Rock in south-central Pennsylvania.

FIGURE 15. Snowball structure in homogeneous shale of the Trimmers Rock one mile west of Port Trevorton, Snyder County, Pennsylvania. Hammer and pocket knife for scale.

Grains could not be distinguished with the hand lens in shales showing snowball structure. In hand specimen the material is very compact, and homogeneity is suggested by lack of primary structure and lack of color variation. When struck with a hammer, snowball fragments break evenly along gently curved surfaces.

Splitting surfaces in snowball structure of the Trimmers Rock are of the same general character as planes of fissility. The two structures differ in that planes of fissility are planar and subparallel to bedding whereas splitting surfaces are not necessarily planar and do not parallel stratification. Additionally, fissile shales are commonly stratified whereas snowball shales are apparently homogeneous. Two hypotheses are therefore suggested: 1) development of fissility is advanced by the presence of stratification; and 2) arcuate splitting surfaces develop in homogeneous fine-grained material. The first hypothesis is in substantial agreement with Ingram (1953, p. 877) and Pettijohn (1957, p. 351). The apparent homogeneity of the shale in snowball structure is perhaps related to mixing by organisms, as discussed later.

SILTSTONE AND SANDSTONE

Coarse-grained conglomeratic sandstones compose the coarsest deposits of the Trimmers Rock, but they are comparatively rare. The finer grained deposits of the Trimmers Rock are represented by a continuous series from fine-grained sandstone to shale, and these rocks constitute the bulk of the unit.

Siltstone and sandstone are described together because a large majority of the beds which contain silt-sized or coarser grains show a range in grain-size from fine silt to medium sand. Mean size also varies within individual beds so that a bed may actually be medium-grained sandstone at the base and fine-grained siltstone at the top.

Texture and Composition

General

Texture and composition of siltstones and sandstones in the Trimmers Rock Member of the Fort Littleton Formation were studied in hand samples and 22 thin sections. Most consist of a disrupted framework of quartz grains in a matrix of fine-grained chlorite, sericite, muscovite, and quartz constituting 20–60% of the rock. Quartz makes up about 90% of the framework and total quartz content of these rocks is estimated at 40–50%. Neither rock fragments nor feldspar attain 5% concentration in any of the thin sections. Rocks of this description fall into the classification of graywacke (Pettijohn, 1957, p. 291). The unqualified term used in the sense of Pettijohn satisfies the rock description without the necessity of resorting to the term quartz graywacke as recommended by Williams and others (1955, p. 294).

Near the top of the Trimmers Rock, sandstone associated with conglomerate displays a different texture. Individual framework grains are in contact, and matrix material is present only interstitially, in amounts generally less than 10%. Average quartz content is estimated at 60–70%, and rock fragments are more abundant than feldspar. Rocks of this description fall in the classification of subgraywacke (Pettijohn, 1957, p. 291).

Matrix

The most obvious textural feature of graywackes in the Trimmers Rock is the well-developed clay-sized matrix. In some thin sections, matrix minerals constitute as much as 50% of the rock, but about 35% seems to be average. In all thin sections examined, fine micas are the dominant minerals of the matrix, and chlorite, although abundant, is subordinate. Sericite and muscovite are the most common matrix minerals and are usually present in approximately equal amounts. Variation in chlorite content ranges from about 10% to a rare 40% of the matrix.

Matrix minerals frequently are seen to penetrate the margins of framework quartz grains. This is most obvious as vague splotches a few microns in diameter of highly birefringent material in re-entrants along quartz grain margins. In places where penetration is extreme, quartz grains have very irregular outlines. Extreme penetration, however, is rare, and the affected grains are always in close proximity to nonpenetrated grains or to grains which are penetrated only slightly by matrix. There is little doubt that penetration represents secondary replacement of quartz by matrix.

Cement

Carbonate cement is present as irregular splotches ranging in size from .02 to .5 mm. Locally, thin veinlets of carbonate are seen to cross-cut matrix and framework grains in thin section. The strongest concentration of carbonate observed is less than 3% of the rock. Precise identification of the carbonate minerals could not be made in thin section, but a few beds effervesce slightly with dilute HCl suggesting that calcite is the dominant carbonate. Iron oxides are also important cementing agents.

Framework

Most quartz grains of the framework are angular to sub-angular, some angularity resulting from embayment by matrix minerals. Grains of plagioclase are generally sub-angular, and mean size is approximately the same as for quartz grains (Appendix C). Replacement of plagioclase by matrix or other materials was not observed; boundaries of plagioclase with other minerals are sharp and regular. Potassium feldspars are generally more rounded than either plagioclase or quartz, in the range sub-angular to sub-rounded.

Commonly, siltstone and sandstone of the Trimmers Rock contain fragments of previously consolidated shale. These fragments are identical in thin section to the shales of the Trimmers Rock. In some cases they occur as swarms near the top of the bed, but generally they are isolated at various positions within the bed (Figure 16). As seen in two dimensions, shale fragments range in size from a fraction of an inch to several inches long and less than an inch wide. Most shale fragments are irregular and angular in outline, and the contact with enclosing siltstone is vaguely defined. The slightly darker gray shale fades into the surrounding lighter gray of the graywacke. Extremities of the fragment, if it is an extended one, may be bent and contorted. In thin section, many elongate shale fragments can be distinguished from animal burrows only with difficulty.

Recognizable heavy minerals in the graywackes of the Trimmers Rock include hematite, zircon, garnet, tourmaline, apatite, and pyrite. Hematite is by far the most abundant heavy mineral, making up more than half of

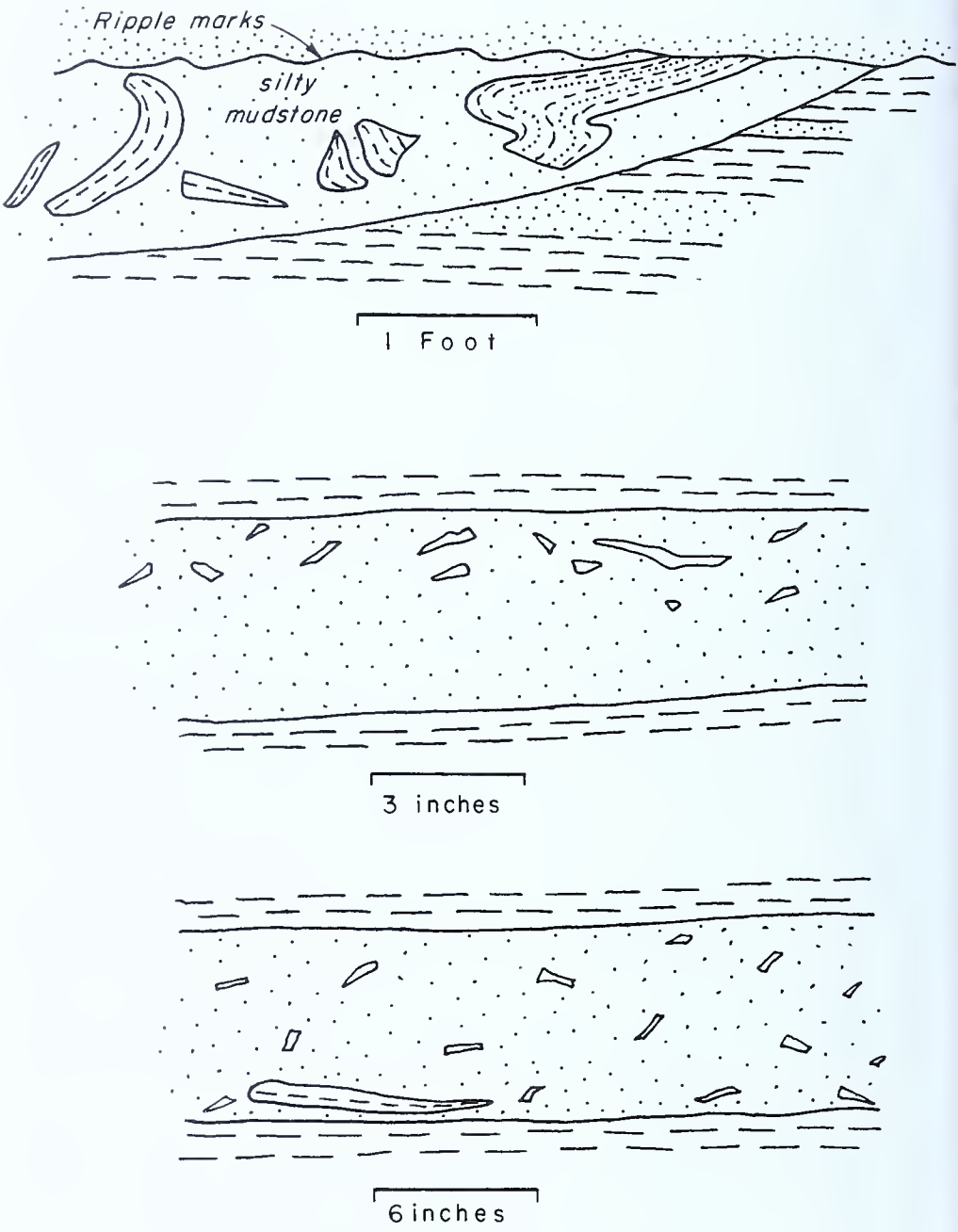

FIGURE 16. Occurrences of shale fragments in graywacke.

these minerals. Hematite occurs in three forms: 1) dark-red-brown irregular grains; 2) light-red-brown to yellow-brown stains spreading outward from the irregular grains; 3) well-rounded blood-red grains.

Zircon is the next most abundant heavy mineral and is generally present in well-rounded form. Zircon does not exceed 10% concentration of the heavy minerals. Garnet, tourmaline, and apatite are rare. Authigenic pyrite is present as abundant but very small euhedral crystals. Because of their relatively small size, pyrites do not constitute more than 2% of heavy minerals.

Subgraywackes of the Trimmers Rock are generally coarser grained than graywackes; most are termed sandstone because their modal size-class clearly falls in the sand-size range. The matrix constitutes 5–15% of the rock, and matrix minerals are identical to those of the graywackes. With the increase in grain-size in subgraywackes, there is a corresponding increase in rounding of grains which is quite marked. In medium-grained subgraywackes, for example, framework grains are sub-rounded to well-rounded. Rock fragments make up 5–10% of the framework in subgraywackes. Feldspar content averages about 10%, comparable to feldspar percentages in the graywackes. Abundant pyrite in minute disseminated crystals is a common characteristic of subgraywackes.

Structure

General

Primary structures in the siltstones and sandstones of the Trimmers Rock are abundant, varied, and unusual; these characteristics of the unit first attracted the attention of the writer. Structures of the more common form, i.e. bedding, are very significant because their study provides a basis for dividing the Trimmers Rock into informal rock units and for determining certain aspects of paleo-environment and paleogeography. Structures which yield evidence bearing on the paleocurrent system are also very useful for interpreting paleogeography.

Generally, siltstone, siltstone-sandstone, and fine-grained sandstone of the Trimmers Rock display three types of bedding. The three are referred to in this paper as: Type I beds, having a discrete top and base; Type II beds, having a discrete base and a top gradational into shale; Type III beds, less than one inch thick and having a discrete top and base. Differentiation of Type I and Type III beds is based on thickness; at thicknesses less than one inch siltstone beds are recognized with difficulty and where observed such thin layers are designated Type III. Beds of Type I bedding character constitute the bulk of the nonshaley portion of the Trimmers Rock throughout the region studied. Types II and III are less common and are restricted geographically.

No mineralogical difference between Types I and II was detected, but Type I beds are generally coarser grained. Sandstones are common in Type I beds whereas Type II beds are all siltstones. Type III beds are mineralogically similar to Type I strata.

Type I Bedding

Type I beds typify the Trimmers Rock Member of the Fort Littleton Formation (Figures 17 and 18). These very hard graywackes and subgraywackes display an apparently random distribution through the dominant bulk of the shales. In places, they succeed one another without intervening shale while in other parts of the section Type I beds are separated by shale units tens of feet thick. Type I beds are more resistant to weathering than shales and commonly form ledges and lips on the outcrop.

The most diagnostic characteristic of the Type I bed is that the intersection of both top and bottom planes with shale is very sharp and regular. There is some variation in the extent to which Type I beds are planar; however, most exhibit remarkably planar contacts for long distances in

FIGURE 17. Type I beds showing planar contacts at top and base and interbedded shales exposed in roadcut at Huntingdon, Huntingdon County, Pennsylvania. Hammer for scale.

outcrop. Type I beds range in thickness from the arbitrary lower limit of one inch to six feet, the maximum observed. Although many Type I beds are graded in thin section most appear massive or structureless.

For Type I beds, characteristics which are very common but not necessarily diagnostic include well-developed joint surfaces and distinctive weathered colors. Two joint systems, generally at about 110° to one another and perpendicular to bedding, frequently cause Type I beds to weather to blocks of thickness equal to bed thickness and 2–6″ in the other two dimensions. Talus fragments of Type I beds have nearly square corners. A distinctive yellowish color (range 10 YR 8 6–10 YR 6 6) is very commonly developed on Type I beds, sometimes in the form of liesegang banding.

Locally, Type I strata have nonplanar contacts with shale and other rock types. The most common type of nonplanar base is that of bulbous or rounded protrusions into underlying shale or siltstone. Type I beds frequently wedge out within an exposure, often in association with such protrusions. Upper contacts of Type I beds also display irregularity, and in the majority of instances these nonplanar surfaces are associated with internal cross-lamination.

FIGURE 18. Type I beds and intercalated shales exposed in roadcut at Girtys Notch, Perry County, Pennsylvania. Siltstone Unit 3. Hammer for scale.

Type II Bedding

The Type II bed is the characteristic rock type of the Brallier Member of the Fort Littleton Formation and a common constituent of the Trimmers Rock Member in central Pennsylvania. In this bedding type the base is sharp and planar but the top is visibly transitional into shale above (Figures 19 and 20). Some Type II beds appear to be superimposed directly on other Type II strata, but close examination reveals the presence of fissility in the topmost portion of the subjacent bed.

Cleavage is developed in the upper portion of many Type II beds. Cleavage planes are usually oriented parallel to the strike of the strata and display a constant dip at some angle to the bedding.

Type II beds are graywackes with the modal size-class always in the silt range; laminae in Type II beds also consist of silt-sized grains. The internal structure of Type II beds is massive and graded; in western Pennsylvania, however, some Type II beds show well-developed current-laminae, which grade upward from the highest lamina into the overlying shale.

FIGURE 19. Type II beds showing distinctive fissility ond poorly defined contacts. In roadcut 2 miles north of Liverpool, Perry County, Pennsylvania. Siltstone Unit 3 in Liverpool section. Hammer for scale.

FIGURE 20. Type II beds in roadcut at Girtys Notch, Perry County, Pennsylvania. Siltstone Unit 5. Ten-cent coin for scale.

Type III Bedding

Most bedding units denoted as Type III are merely thin lithic equivalents of Type I beds. At thicknesses less than about one inch, however, these strata do not weather into relief as do thicker beds and are therefore not always distinguishable from enclosing shales. Type III beds are probably lateral equivalents of both Type I strata and of silty laminae in shales.

In thin beds with distinct boundaries, variation of mineralogy and grain size seems to be greater than in Type I beds, and for purposes of simplification all such diverse strata are included under Type III. The framework of most Type III beds consists of medium-silt to fine-sand, but a few layers noted in Appendix A consist of coarser material. At Shamokin Dam a few Type III beds are very coarse sand; some contain granules of white vein quartz. An unusual light-red-brown color suggests that other Type III siltstones differ mineralogically but this possibility cannot be evaluated without considerable petrologic study.

Because of their comparatively small thicknesses and wide spacing, Type III strata seldom constitute an appreciable percentage of the section measured. For this reason Type III beds are not considered a prominent characteristic of the Trimmers Rock.

Description of Cross Stratification

The only internal structure readily discernible in most graywackes of the Trimmers Rock is preferred orientation of the platy matrix minerals seen in thin section. Infrequently, however, horizontal laminae are developed throughout the thickness of the bed, or more commonly, in the upper half of the bed. Slightly higher in these latter beds, cross laminae may be present. Laminae are spaced at intervals from less than a millimeter to about 3 millimeters in both types. Cross laminae are inclined to the plane of the bed by as much as 30° and are usually truncated by set boundaries (Figures 21 and 22). The curved cross lamina is by far the most common feature of the coset (McKee and Weir, 1953, p. 382). Sets vary in thickness from about a millimeter to two centimeters, averaging about half a centimeter.

In vertical section most cross laminae of the Trimmers Rock are gently concave upward. Sections parallel to the bed reveal that sets are also curved in plan view. It is difficult to determine the geometry of the internal structure without complete dissection of the cross-laminated bed, and this procedure is not practical in the field. For this reason orientation of cross lamina was not measured for the purpose of determining current direction.

The geometry of the internal structure may be deduced, however, from the external form as revealed on sandstone and siltstone beds. The surfaces of many beds display ripple marks (Figures 23 and 24) although preservation is generally poor, and the top surfaces of graywackes are seldom exposed for an area larger than a few square feet. Ripple-marked soles occur in the Trimmers Rock; this seldom-noted structure is developed in the subjacent bed, which may be sandstone, siltstone, or rarely, shale (Figure 26.) Quite commonly the graywacke bed is laminated in outcrop; by exposing the top of the bed, it is sometimes possible to relate internal cross-lamination to the external form, ripple mark.

In plan view, ripple marks are either continuous linear features (Figure 23) or they are discontinuous linear features broken into a dimpled pattern by a series of low saddles in the troughs (Figure 24). Saddles are somewhat irregular in their spacing, but most commonly spacing is approximately twice the wave length. Each saddle is limited to the area between two adjacent ripple crests. Individual segments of the discontinuous trough therefore have a scoop-like shape, the lowest portion being intermediate between two saddles. Viewed longitudinally, discontinuous ripple marks display marked linearity, the interrupted scoops occupying the ripple trough.

In order to determine the relationships between discontinuous ripple mark and cross laminae, a rippled Type I bed was dissected. Structure of the bed is shown in Figures 21 and 22. The bed examined is 3 inches thick and shows laminae consisting of alternating light, quartz-rich layers and dark, clay-rich layers. The laminae are typically grouped by similar orientation into sets, which are bounded by planar or curved surfaces. In the bed examined, 18 sets

of laminae are distinguished, and their bounding surfaces are delineated by heavy lines in the figures. Figure 22B shows the rippled form of the bed top.

Many laminae approach parallelism to the slightly inclined bounding surface at the base of the set. Inclination decreases upward so that the youngest laminae of the set are usually almost horizontal. In many cases, laminae occur in the form of climbing ripples (sets 1, 3, 4, 5, 14, 15). The top bounding surface abruptly truncates laminae of the set in every example. Accordingly, the top bounding surface is erosional in origin. The pattern of erosion is indicated by the configuration of the set boundary on the cut surfaces.

Set 1 is truncated at the top by a moderately irregular surface which appears to be rippled (Figures 21A, C). The structure is similar in form and orientation to the ripples on the top of the bed (Figure 22). Laminae beneath this boundary are essentially horizontal and discontinuous and do not conform to the rippled shape of the bounding surface. The same relationships are seen at the top of sets 3 (Figure 21C), 7, 12, 14, and 16. Other sets are cut off at the top by smooth, curved surfaces which may be portions of a ripple-marked surface. Three sets (4, 5, and 15) are cut by bounding surfaces which are nearly parallel to laminae in the underlying set.

The curved set boundaries are also revealed on the horizontal surface of Figure 21B. Sets 9 and 10 were deposited in shallow scoop-like, erosional depressions aligned parallel to ripple marks on the bed top. Other forms occur in sets 1, 2, 4, 5, and 6 (Figure 21C). These structures are considered to represent the basic unit in the formation of discontinuous ripple mark. Every set shown might be considered to display the following form: 1) on horizontal surfaces, contacts between sets tend to be parallel to ripple mark; 2) on surfaces cut normal to ripple mark, set boundaries are rippled, irregular, and discordant; and 3) on surfaces cut parallel to ripple mark, set boundaries are nearly planar, and laminae are inclined only slightly to the horizontal.

Interpretation of Cross Stratification

The formation of a set began with erosion of the soft sediment of the underlying set, resulting in a scooped trough aligned normal to the direction of flow. Into these relatively low areas the current deposited the inclined laminae of the set by building forward in the direction of flow. The youngest laminae were laid down in the form of ripples which were no longer controlled by the configuration of the scooped base (set 14). These erosional scoop-areas, corresponding to interrupted ripple troughs, were bounded at either end by noneroded, relatively high areas represented by saddles of discontinuous ripple mark.

Type I beds with cross laminae are generally quite constant in thickness through long exposures, in contrast to the marked lenticularity of sets in detail. This suggests that overall build-up of the bed resulted from sedimentation out of the current and that redeposition of eroded material from one set to

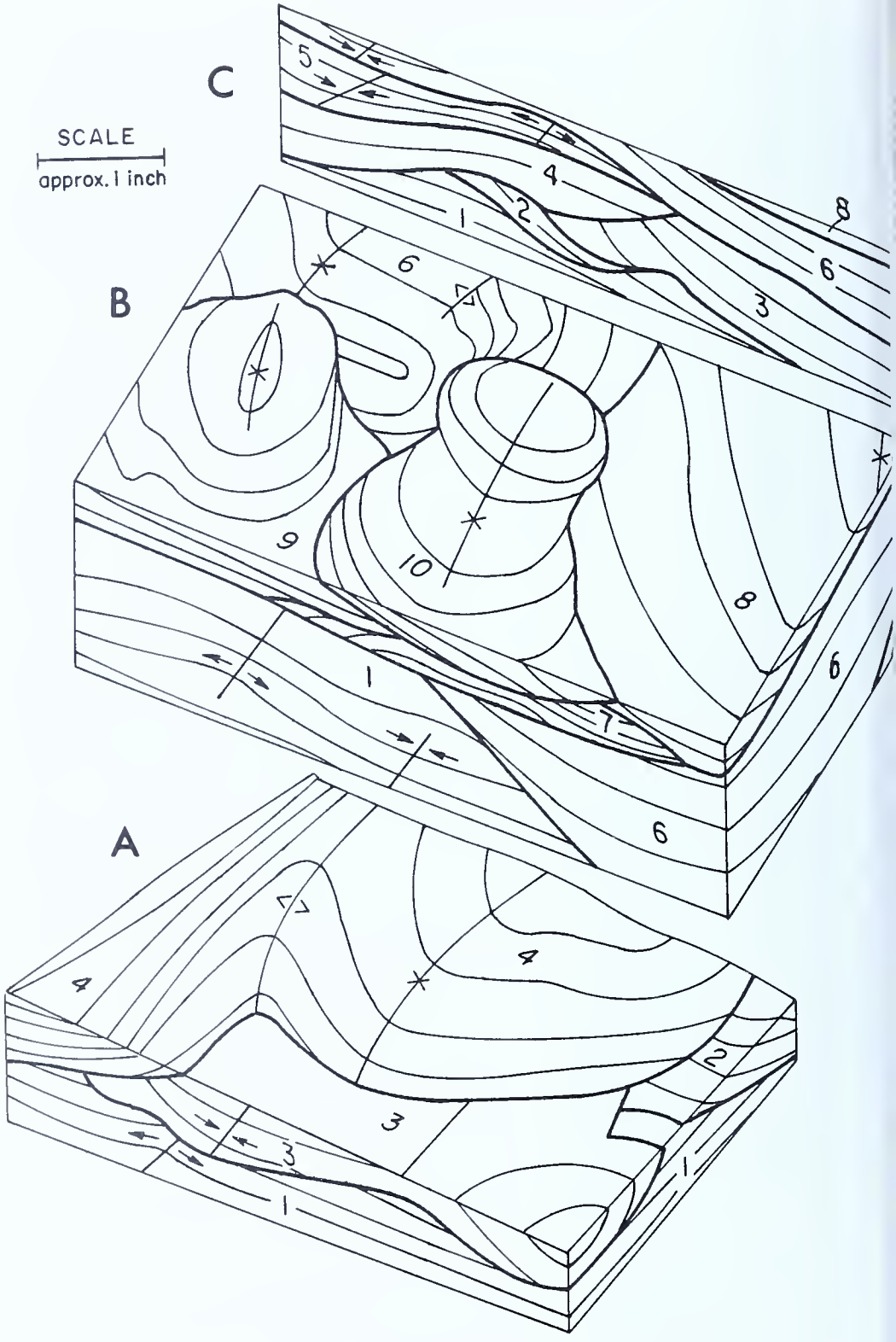

FIGURE 21. Sections through discontinuous ripple marks.

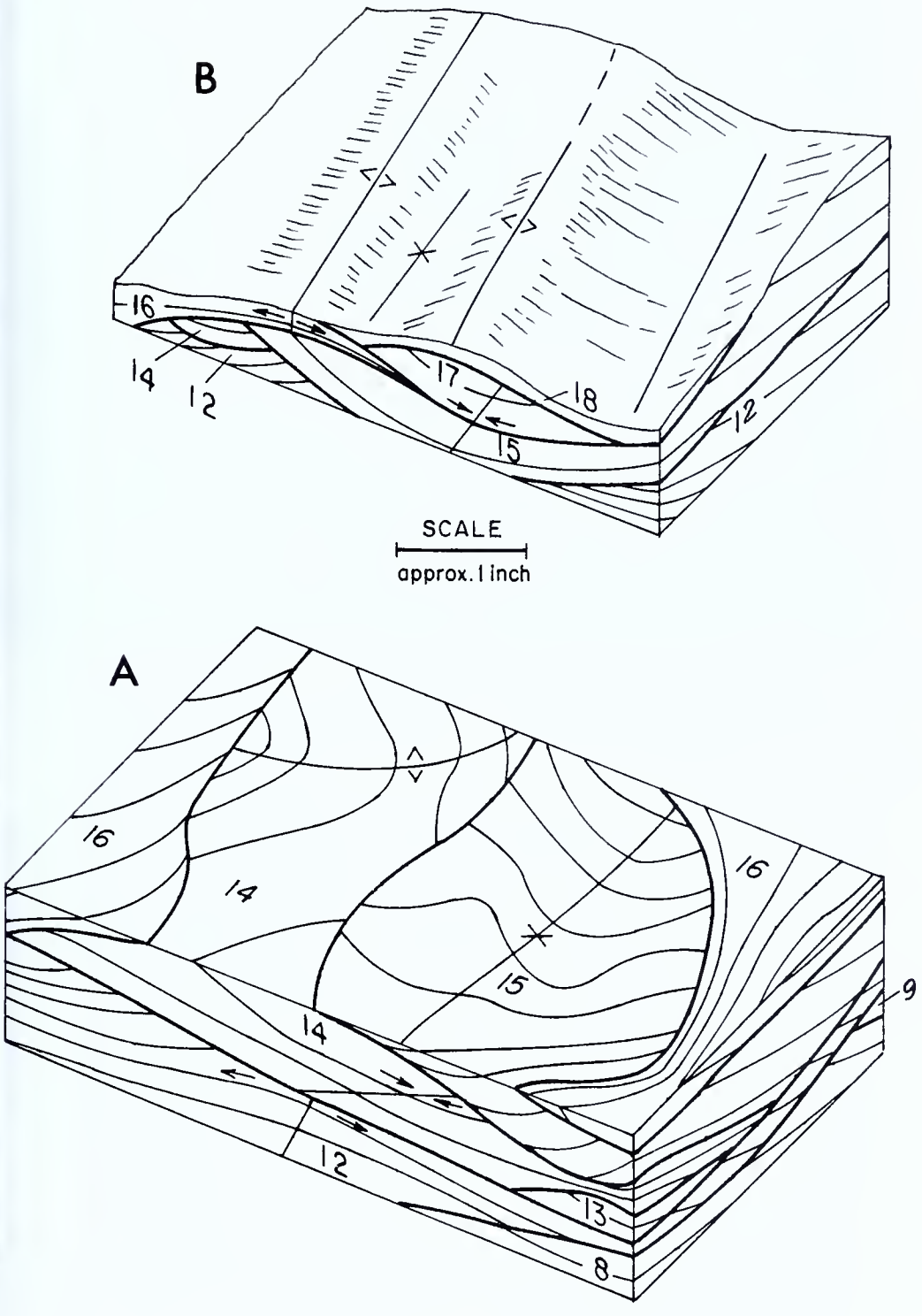

FIGURE 22. Sections through discontinuous ripple marks.

FIGURE 23. Ripple marks of small amplitude exposed an a bedding surface in Siltstane Unit 3 at Millrift, Pike County, Pennsylvania. Port Jervis section. Pencil far scale.

another was a minor process. The fact that the largest grains in the coarser laminae are medium-silt to very fine-grained sand indicates that additional sediment might have been made constantly available by settling from suspension; the ripple-blanketing nature of set 18 provides strong support for this idea.

The formation of cross stratification has been related to migration of ripple marks by Sorby (1859) and elaborated on more recently by McKee (1938), Niehoff (1958) and Allen (1963). For the simple case of continuous ripple mark, Sorby (p. 141-144) postulated formation of inclined laminae from building-forward of lee-side laminae of ripple mark. Allen (p. 204-209) investigated the effects of deposition from suspension concurrent with ripple migration to explain the overall build-up of the cross-stratified bed. The more varied and complex cross laminae deposited in erosional scoops were attributed by Allen (p. 215-217) to migration of linguoid ripple marks with or without simultaneous deposition from suspension. Niehoff (p. 266) arrived at a similar conclusion from analysis of the internal structure of beds in the Koblenz Quartzite.

FIGURE 24. Discontinuous ripple marks exposed on a bedding surface in Siltstone Unit 3 near Millrift, Pike County, Pennsylvania. Port Jervis section. Note saddles separating scoop-shaped depressions in the ripple troughs. Hammer for scale.

The external form of discontinuous ripple mark is similar but not identical to various forms termed interference ripple mark (Kindle, 1917, p. 34; Twenhofel, 1926, p. 473; Shrock, 1948, p. 117). Discontinuous ripple mark differs significantly from linguoid ripple mark (Allen, 1963, p. 214) in that crests are linear and rarely broken. The internal structure of discontinuous ripple mark is similar to that of festoon cross-bedding as described by Knight (1929, p. 56) and Pettijohn (1957, p. 169–170). The most critical difference between cross laminae in scoops of the Trimmers Rock and festoon cross-bedding is that Trimmers Rock beds display ripple crests in sections normal to scoops, and also on bed tops. The scale of structures is also markedly different in that sets in the Trimmers Rock average less than one inch thick, whereas sets in festoon cross-bedding are commonly on the order of ten feet thick.

The scoop-shaped sets in discontinuous ripple mark originated by erosion of underlying sets; the question of most importance is whether erosive currents operated normal to or parallel to the scoops. Both the internal and external structure support the contention that the current flowed normal to

the scoops. This interpretation differs from that applied to scoops in festoons and those formed by migration of linguoid ripple marks, in which the current is thought to have flowed parallel to the scoop.

The structures observed on sections parallel to the base of the bed are similar to those described by Hamblin (1961) and termed micro-cross-lamination and to rib-and-furrow structure (Stokes, 1953, p. 17). The conclusion that the current flowed parallel to the axis of the structure is questionable because in some areas rib-and-furrow is oriented parallel to ripple mark (Picard and High, 1964, p. 30–31).

A total of 226 ripple marks, including 14 discontinuous ripples, were measured in the course of this study. Ripple mark was measured only when three or more crests were visibly parallel. Measurements included orientation, wave length, and amplitude (Appendix B). Mean wave length for all ripples measured is 4.15 inches with standard deviation 1.03 inches. Mean amplitude is .57 inches and amplitude standard deviation .26 inches. The average ripple index for these observations is 7.28. Ripple mark wave length and amplitude are correlated positively with $r = .577$, which is significant at the .1% level (Table 1).

In a very few instances, cross-laminae are associated with convolute bedding (Kuenen, 1953, p. 1056) near the top of Types I and II beds. Typically, troughs in convolute bedding are flat-bottomed and expanded while crests are peaked and inclined. Inclination of crestal planes, however, is not consistently in one direction for a single outcrop. The formation of convolute bedding is possibly related to contemporaneous current drag and gravity-loading of ripple troughs as suggested by Kuenen (1953, p. 1057).

		AMPLITUDE (INCHES)								
		¼	½	¾	1	1¼	1½	1¾	2	TOTALS
WAVE LENGTH (INCHES)	¼—1	6								6
	1 ¼—2	14	16							30
	2 ¼—3	14	37	6	3					60
	3 ¼—4	6	26	9	5					46
	4 ¼—5	1	18	16	8	1	1			45
	5 ¼—6	2	5	6	3					16
	6 ¼—7	1	4	4	2					11
	7 ¼—8		2	2	2					6
	8 ¼—9			2	2					4
	9 ¼—10									0
	10 ¼—11									0
	11 ¼—12			1						1
	12 ¼—13									0
	13 ¼—14								1	1
	TOTALS	44	108	46	25	1	1	0	1	226

TABLE 1. *Positive correlation ($r = .577$, which is significant at .1% level) of ripple mark wave length and amplitude for 226 measured ripple marks. Each row and each column shows roughly normal distribution.*

Larger scale cross stratification (McKee and Weir, 1953, p. 382) is locally present in Type I beds. Cross-stratified sets range in thickness from about 3 inches to one foot, averaging about 9 inches. Individual cross-strata average about $\frac{3}{4}$ inch thick and are planar in form. Large-scale cross stratification is most abundant in the western sections.

Sole Irregularities

The soles of Type I beds are generally planar to a remarkable extent, but commonly they show vertical irregularity measured in inches. Irregularity consists of downward protrusions into shale or siltstone and associated upward bowings or intrusions of shale. Two genetically different types of irregularity can be distinguished on a descriptive basis: 1) contact-parallel structures; and 2) truncated structures. Both structures result from relief present on the top of the subjacent bed prior to deposition. However, such relief features are modified in many cases by the process of depositional loading.

The form of many beds showing deformation by the process of depositional loading is similar to the structures termed flow casts (Shrock, 1948, p. 156), flow rolls (Rich, 1950), and ball- and- pillow structure (Potter and Pettijohn, 1963, p. 148).

Contact-parallel structures are represented by infilling of a ripple-marked surface or other, less regular, structural features on the top of the subjacent bed (Figure 25). In cases where the underlying bed is siltstone or sandstone, ripple mark is identified by current laminae parallel to the ripple form and within the lower bed.

Contact-parallel structures are generally depositionally loaded. On several soles loaded contact-parallel structure has the same orientation as ripple mark in adjacent beds and close parallelism is abundantly demonstrated. It is probable, therefore, that contact-parallel structures with extended long axes originate from depositional loading of ripple mark (Figures 26 and 27).

Depositional loading was postulated by Kuenen (1949, p. 372) for similar structures in the Carboniferous of southern Wales. Pepper and others (1954, p. 88) attributed identical structures in the Berea Sandstone of eastern Ohio to contemporaneous deposition and sinking. The transverse ripple-load-casts of Kelling and Walton (1957, p. 485) are also identical to loaded ripples in the Trimmers Rock.

Truncated structures at the bed base are irregular in plan and variable in relief up to a few inches. These structures apparently result from deposition on an uneven surface. Laminae in both the overlying and underlying bed locally truncate against the margins of these structures, suggesting that irregularity originated by erosion of the substratum prior to deposition of the overlying bed. Truncated structures may be much more widespread

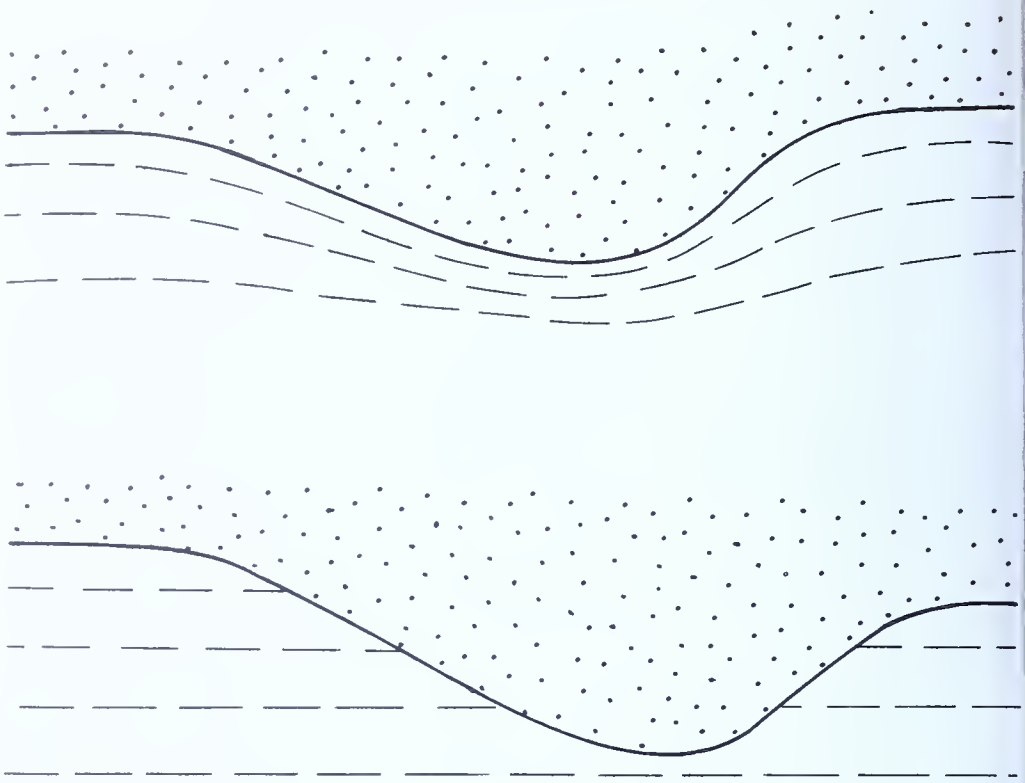

FIGURE 25. Diagrams shawing contact-parallel and truncated structures.
Cantact-parallel structure (abave)
Truncated structure (belaw)

than noted because the scarcity of laminae in the Trimmers Rock makes recognition of the structure difficult.

Widespread erosion contemporaneous with deposition of the Trimmers Rock is suggested by the abundance of semi-consolidated shale fragments in the graywackes, by the pre-depositional nature of many trace fossils, and by the frequency distributions of bed thickness. Because of the planar aspect of most beds, erosion must have been most effective in removing thin sheets of sediment. Truncated structures, on the other hand, are indicative of more localized, more irregular erosion.

The process of depositional loading has affected truncated structures in some instances. The criterion for recognition of this development is the oversteepening of laminae in the superjacent bed (Figure 25).

Bolster Structure

A type of load-structure common in eastern exposures of the Trimmers Rock consists of structures similar to the foregoing description except that the sandstone and siltstone bodies of elongated ellipsoidal form are *completely isolated* from a continuous bed. These isolated bodies are referred to here

FIGURE 26. View upward in railroad cut at graywacke sole. Shamakin Dam, Snyder Caunty, Pennsylvania. Siltstane Unit 3. Ripple marks an sale are caunterparts of structure in underlying shale, Note slightly divergent groove casts. Ripple mark wave length abaut 6 inches for scale.

FIGURE 27. View upward at graywacke sale in railroad cut, Shamokin Dam, Snyder Caunty, Pennsylvania. Siltstane Unit 3. Depasitianally laaded ripple marks oriented parallel ta ripples in Figure 26 and ta other ripples in the same section. Average wave length af structures is abaut 4 inches.

as bolster structures because of their characteristic shape. The structures occur tens of feet apart along the same stratigraphic level at Port Jervis for a distance of at least several hundred feet and are separated by undisturbed shale (Figures 28–30).

In the course of field work, the axes of ellipsoids which could be seen clearly in three dimensions were measured. For 36 observations all long axes lay in or nearly in the plane of bedding and averaged 21.1 inches in length. For the same structures the intermediate axis was in the plane of bedding in 34 (94%) of the occurrences and averaged 10.7 inches long. The shortest axis in these structures averaged 7.5 inches in length. Ratio of ellipsoid axes therefore averages about 2: 3 : 6.

At the margins of the bolster, shale is deflected downward and parallel to the boundary. Within the structure, stratification is well developed. Near the margin, synformal stratification is consistently paralled to the contact with shale, and as a result of depositional loading contemporaneous with deposition, the layers may be overturned. Because each internal layer thins on the flanks and thickens in the trough, stratification is progressively more horizontal toward the top of the bolster (Figure 31).

FIGURE 28. Isalated bolster in poorly fissile shale near Millrift, Pike County, Pennsylvania. Siltstone Unit 3 in Port Jervis section. Note decrease in synformal dips upward in the structure indicating formation by depositional laading. Pencil at right far scale.

FIGURE 29. Large bolsters separated by shale in road-metal quarry near Part Trevorton, Snyder County, Pennsylvania. Hammer far scale beneath balster layer.

FIGURE 30. Small balsters separated by shale. Siltstane Unit 9 at Shamokin Dam, Snyder County, Pennsylvania. Nate cancentrotion of balsters alang definite stratificatian planes. Brunton campass for scale.

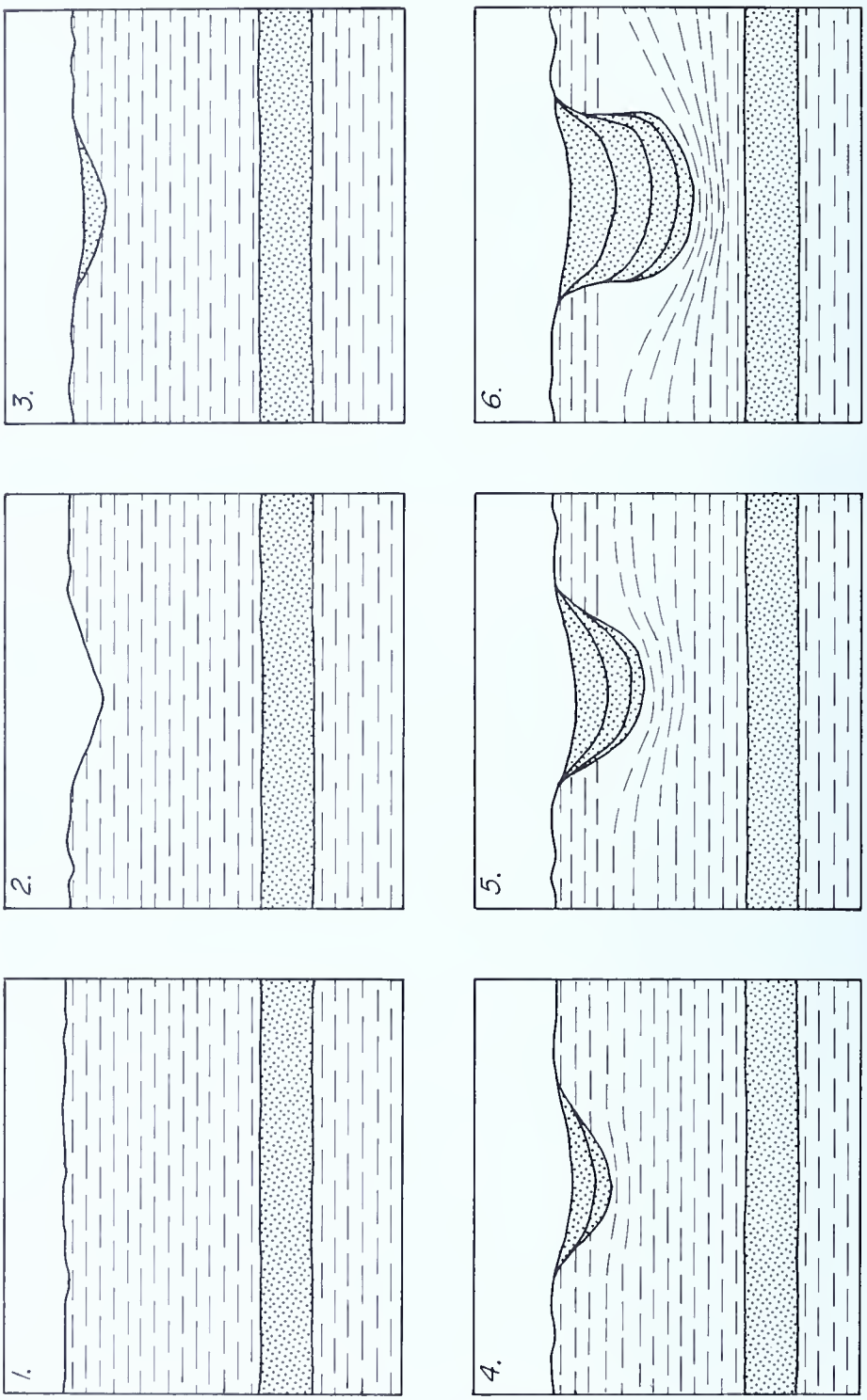

FIGURE 31. Development of a bolster on eroded substratum. View parallel to longest axis.

The nature of stratified bolsters requires that sinking or depression by loading took place concurrently with deposition. This is illustrated by the high inclination and overturning of stratification adjacent to the margin of the body. Horizontal stratification at the top of the load-structure indicates that depression of the bolster ceased with deposition. The occurrence of bolsters along the same plane of sedimentation suggests that the current carrying the sand and silt began to deposit its material in isolated areas which were slightly lower than the general surface over which the current moved. Because the structures themselves have strong parallelism, the original low areas must have had similar alignment. Orientation of the low areas was probably the result of some directional force in the environment; the most likely cause is the current of deposition. In a few places, bolster structure is roughly parallel with nearby ripple mark.

Flame Structure and Cord Structure

Shales adjacent to bolsters and between irregularities on soles are in many cases disturbed from their normal parallelism to the outcrop attitude. In some examples, shales near the margin of the lower half of a loaded structure is clearly warped down. By far the more common structure, however, is the *upward* protrusion of shale in the form of a sharp ridge between closely spaced load-structures. These are termed flame structures (Kelling, 1958, p. 121).

In detail, the intersection of flame structure with the continuous part of the overlying bed is represented by a series of sharp indentations separated by rounded areas in the bed or on the sides of load-structures. Total relief is only a fraction of an inch, but the structure may be several feet long. These features are referred to as cord structures because the name is descriptive of their appearance (Figure 32). As expected, cord structures are closely parallel to flame structures, and many are parallel to the long axes of bolster structures.

Landslide Deposits

Frequently bolsters and associated structures occur in zones which show evidence of having moved laterally as well as downward during their development. These zones are considered to represent fossil subaqueous landslide deposits. Lateral movement is demonstrated in certain layers up to 20 feet thick in which separated bolsters and blocks are dominant constituents (Figures 33 through 38). Several criteria were recognized to establish lateral movement; all criteria do not occur together in any one outcrop, and only one criterion is considered necessary to demonstrate movement, provided the evidence is unequivocal and the recognition characteristic is of good quality.

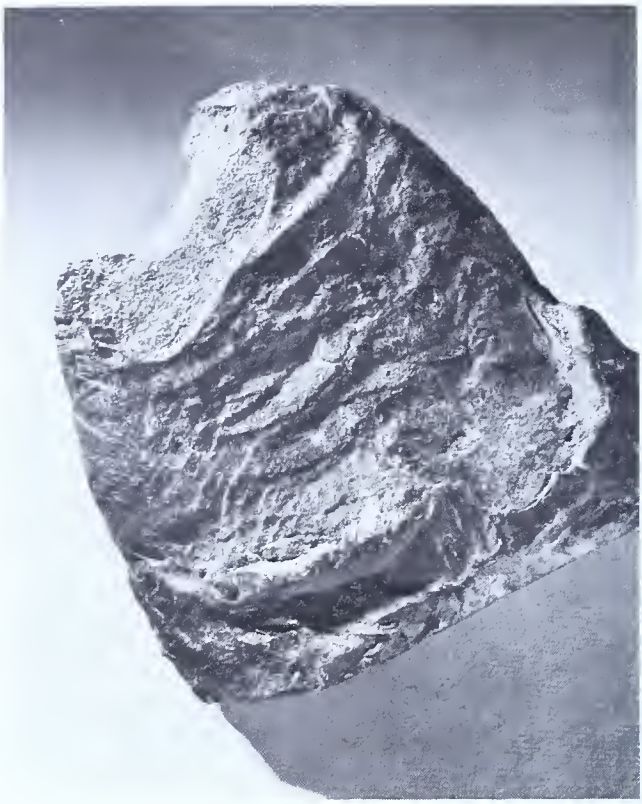

FIGURE 32. Cord structure on sole of bolster structure. Block is 10 inches long.

Criteria for the recognition of lateral movement are listed as follows together with examples:

1) overturned bolsters, as determined by shape. Unit 70, Juniata River.
2) presence of subangular blocks. Unit 5, Port Jervis; unit 111, Catawissa.
3) marked erosion of the substratum. Unit 115, Catawissa; unit 23, Liverpool.
4) bolsters or blocks of two or more distinct rock types in disordered arrangement. Amity Hall, Perry County.
5) great variation in size of bolsters. Unit 49, Shamokin Dam.
6) tightly packed bolsters in contact but not pressed into one another. Unit 48, Red Cross.
7) drag marks on the substratum and the bolsters. Hawns Bridge, Huntingdon County.

The reasoning behind each criterion is different to a certain extent and will be described briefly.

In some thick layers of landslide debris, bolsters are oriented at various angles to the attitude of the outcrop. Since the sole is always curved, sometimes enclosing an arc exceeding 180°, there are many examples which might

be explained by in-place preferential loading in a direction inclined to the vertical. When the tangent to the bottom of the trough of the bolster is inclined at greater than 45° so that more than half the sole is vertical or overturned, it is considered unlikely that the bolster is in place (Figure 39.) Overturned bolsters, representing laterally moved structures, are common in the Juniata River section (Figure 35) in unit 148 at Red Cross, and roadcut exposures along Route 22 north of Amity Hall, Perry County.

At Amity Hall, Catawissa, and Red Cross (Appendix B) subangular blocks up to 12 feet long are commonly included in thick layers of jumbled bolsters (Figures 33 and 38, middle). These siltstone bodies are actually fragments broken from various beds and moved laterally. In unit 3 at Port Jervis, a block 18 inches thick and 6 feet long has slid north about 10 feet from the broken end of its bed and less obvious examples are abundant in other localities.

The greatest amount of contemporaneous erosion observed in the Trimmers Rock occurs at the base of landslide deposits. Erosion not associated with slide deposits is of much less magnitude. In unit 23 in the Liverpool section,

FIGURE 33. Zone af laterally maved bolsters and blocks, in roadcut 2 miles north of Amity Hall, Perry County, Pennsylvanio. Such structures are notably conspicuaus by occurring in the midst of sequences of highly planar beds. Pocket knife for scale at left center.

FIGURE 34. Thick zone of laterally moved bolsters and blocks replaced up-dip (toward the left) by disturbed shale. Siltstone Unit 9 at Shamokin Dam, Snyder County, Pennsylvania. Hammer for scale.

at least 3 feet of section is truncated by the base of such a zone 13 feet thick (Figure 37.) Missing section increases from north to south over a distance of about 20 feet, and a wedge of landslide debris occupies the resulting depression. Lateral movement of considerable magnitude is demanded to remove so much material from beneath the layer.

The Amity Hall section contains several exposures of piled-up bolsters consisting of two distinct rock types (Figure 35). The first rock type is the siltstone and very fine-grained sandstone which characterizes most bolsters of the Trimmers Rock. The second lithologic type consists of a silty shale matrix and abundant fossil fragments which constitute 60-70% of the rock. Both types occur in the form of the typical bolster with a rounded base. The fossil-fragment structures are slightly smaller than most bolsters, averaging about 4 inches in the long dimension, and are scattered nonsystematically among the siltstone bodies in the outcrop. Lateral movement of more than one stratum is the only logical explanation for such mixed bolsters, but in most layers of jumbled bolsters distinction of more than one rock type is not possible.

Great variation in bolster size suggests lateral movement of multiple beds because in-place load-structures of a single bed are generally of nearly equal size. In many landslide deposits, however, the long dimension of bolsters ranges from an inch to several feet. Bolster size is apparently randomly distributed through the layer and it is therefore likely that bolsters were derived from several loaded beds and mixed together during movement.

In thick jumbled layers of bolsters there is usually a paucity of shale, and the individual forms are piled on top of one another (Figure 33). In some cases where the shape of the bolsters can be seen in three dimensions, their curved bases rest on underlying forms without penetrating them or conforming to their configuration. Since shale is not present near the contact of the two structures and the boundary is not conformable, the material into which the higher load-structure was pressed is no longer present. The simplest explanation is that the individual structures originated elsewhere by depositional loading and have moved laterally into their present position. Such load-structures may have originally been either irregularities on the sole of a bed or completely isolated bodies.

FIGURE 35. Slide structure cantoining mixed lithologies. Small bolster at one o'clock fram end of hammer handle consists of fossil frogments in a muddy matrix while ather bolsters in the zane are typical Trimmers Rock graywackes. Note that stratification in the largest bolster describes an arc concove downward. Two miles north of Amity Hall, Perry County, Pennsylvania. Hammer for scale.

Movement of landslides might be expected to have marked the surface of the substratum, but this is substantiated with difficulty because the substratal surface is seldom exposed. The only locality at which substratal markings were discerned is a road cut ¼ mile west of the village of Hawns Bridge, Huntingdon County. The town lies 4 miles south of Huntingdon. In this cut the top of the substratum shows closely spaced grooves about 1/16 inch deep, 1/16 inch wide, and 4 inches long. The grooves are oriented N20°W-S20°E. The top ½ inch of the substratum shows tiny folds with vertical axial planes striking about N80°E. Movement of the overlying material in a direction N20°W is strongly suspected.

The regional environmental significance of deposits displaying evidence of lateral movement is discussed in the section devoted to paleogeography. It should be noted here, however, that determination of source area could not be accomplished through study of lithologic characteristics of the moved material. The dominant rock types of the moved blocks and bolsters are identical to the regionally distributed rock types of the Trimmers Rock. For this reason deposits indicating movement are considered to have originated from within the area of deposition of the Trimmers Rock, but the extent and direction of lateral movement can best be inferred from geographic distribution of structures and detailed stratigraphic study.

FIGURE 36. Base of slide zone 8 feet thick, at Meiserville, Juniata County, Pennsylvania. Beds below structure are about 2 inches thick.

FIGURE 37. Erosion at base of slide structure, Siltstone Unit 9, Perry County, Pennsylvania. Note that approximately 3 feet of section below the structure is removed from top to bottom of the view. Large bolster at base of cut is 3 feet in diameter.

A certain sequence of events seems to be required to explain the various characteristics of deposits suspected of lateral movement. Because the dominant constituents of many such deposits are identical to structures originating from depositional loading, it is probable that loading was the first event in the process. The associated angular blocks suggest that some deposits originated from tabular beds, possibly having loaded bases. Second, lateral movement by viscous flow or sliding is required to satisfy the movement criteria cited. Extent and direction of movement is not obtainable from examination in most deposits; several inches may be sufficient to explain some examples, but the possibility that much larger distances are involved cannot be overlooked. Third, redeposition of the moved material is necessary to explain the final relationships preserved in the rocks.

Assuming that individual bolsters and blocks originated as described, a force must have existed which caused lateral movement. Several such forces have been suggested by Dott (1963, p. 110-111) including a gravity component of the sediment mass directed down the slope of deposition.

That slopes of deposition for the Trimmers Rock were gentle is indicated by the great degree of regularity of stratification. Forces resulting from the downslope component of gravity should seemingly therefore have been small.

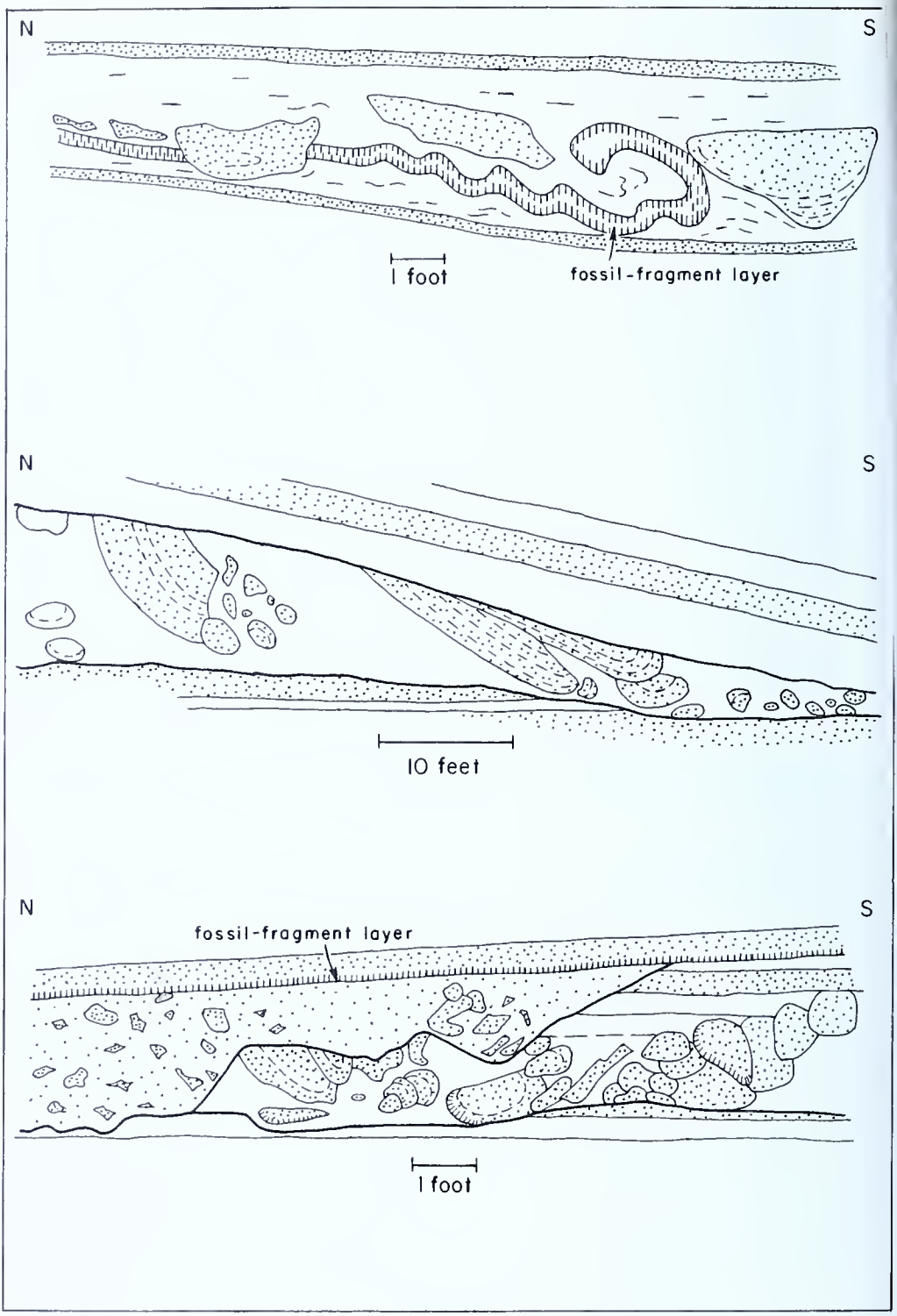

FIGURE 38. Slide structures.
Early stage of lateral movement at Trimmers Rock (Tap)
Laterally moved balsters and blacks at Amity Hall (Middle)
Two distinct slide structures at Amity Hall (Bottom)

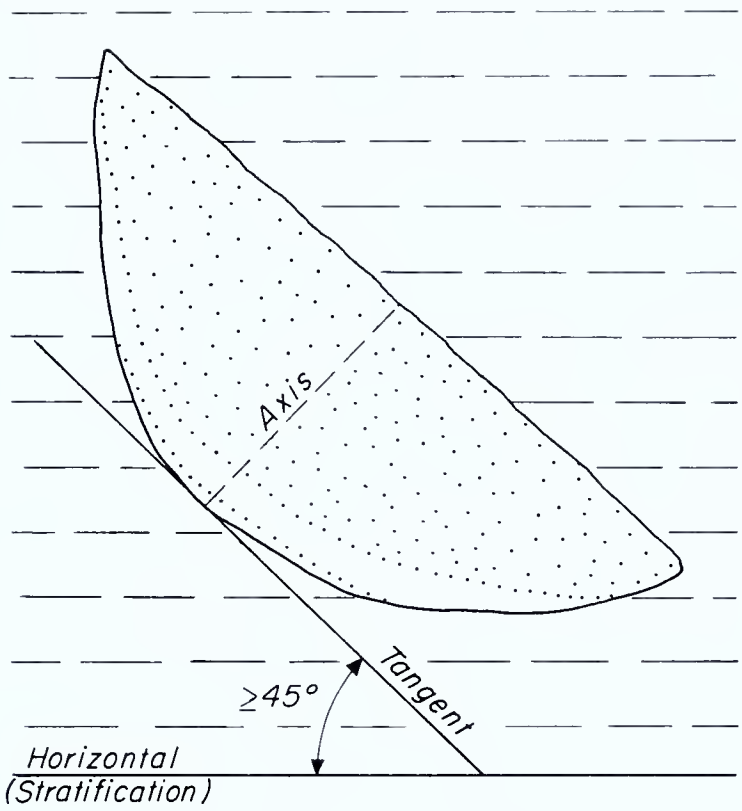

FIGURE 39. Definition of overturned bolster.

If, however, in the process of loading, water saturated mud beneath individual bolsters or beneath a tabular loaded bed were compacted so that pore pressure increased relative to the overburden pressure, a small gravity component due to slope might be sufficient to cause lateral movement. This principle, put forward by Hubbert and Rubey (1959) to explain large-scale tectonic structures, might be applied in the present study to the case of the tabular bed with irregular loading. A large portion of the bed might thus be subject to an increased downslope component of the mass of the bed resulting in breakage, downslope movement, and redeposition as a jumbled mass. Because bolsters in the jumbled mass are discrete bodies and seldom deformed it is necessary that the loaded bed remained in place after deposition until the bolsters, but probably not the enclosing material, acquired a degree of cohesion. The time required for this is not known.

An alternative explanation for the occurrence of jumbled load structures in shale has been advanced by Kuenen (1958, p. 17-21) and considered as the mode of origin for ball-and-pillow structure by Potter and Pettijohn (1963, p. 148-152). In tank experiments Kuenen produced structures greatly similar to bolster structures of the Trimmers Rock and to "pseudo-nodules" from

the Devonian of the Ardennes (Macar and Antun, 1950). Layers of sand were laid down on a subaqueous surface of clay, and the tank was then jolted. The resulting sand balls are attributed to origin from earthquakes simulated by jolting of the tank.

Kuenen (1958, p. 20) offers a substitute for strict depositional loading by earthquake-induced thixotropic behavior of mud. Kuenen further suggested a spectrum of deformation from the mechanism of slumping or sliding at one end to "quake load-casting" at the other. In sequences such as the Trimmers Rock which contain an abundance of loaded structures throughout great thicknesses subaqueous landsliding seems to have been operative but was probably not the dominant process.

Sole Marks

In addition to the internal structures which have been the topic for discussion up to this point, graywackes of the Trimmers Rock also contain strictly external, current-formed structures. These include flute casts, groove casts, and prod casts on the graywacke sole.

Flute casts (Crowell, 1955, p. 1359) are ridges on the sole with a bulbous up-current termination and a gradually diminishing opposite end. Flute casts are sandstone or siltstone casts in depressions scoured by current action in the underlying shale. Although flute casts are not abundant in the Trimmers Rock, 20 measurements were obtained; these are given in Appendix B. Mean length is 2.64 inches with standard deviation 2.08 inches; mean width is .78 inch with standard deviation .56 inch. Mean depth was not calculated because of poor measurability.

Groove casts (Shrock, 1948, p. 162-165) occur as parallel to subparallel ridges on the graywacke sole (Figure 40). Observed groove casts total 112 and these range from a fraction of an inch to over two feet long. Mean length is 4.07 inches with standard deviation 4.15 inches. Mean width is .21 inch with standard deviation .26 inch. Groove cast length and width are correlated positively with $r = .720$, which is significant at the .1% level (Table 2). Depth averages about $\frac{1}{8}$ inch with a small range but depth cannot be easily measured in most cases. Groove casts are generally scattered on the sole and separated by several inches of undisturbed bedding plane.

Groove casts are thought to originate from the cutting action of various tools carried by the current which deposited the overlying bed (Crowell, 1955, p. 1358).

Positive correlation of groove cast length and width indicates either that large tools were dragged along the bottom for a greater distance than small ones or that drag-distance was directly related to amount of surface area of the tool in contact with the bottom.

Prod casts (Dzulynski and others, 1959, p. 1116) are not abundant in the Trimmers Rock, but 10 structures were measured and are included in Appen-

dix B. Superficially, prod casts resemble certain pre-depositional trace fossils oriented at a high angle to the bedding, but prod casts can be distinguished by having a greater degree of irregularity. Prod casts are believed to represent infilling of small depressions caused by impact of a current-driven tool.

Furrow Casts

Another structure commonly associated with current lamination and ripple mark in the Trimmers Rock graywackes is the furrow cast (Figure 41). This structure, named by McBride (1962, p. 58) from the Ordovician Martinsburg Formation of the Appalachians and described by Winterer (1964) from Eo-Cambrian strata of Normandy, consists of a series of closely spaced ribbon-like bands which occur on the bed top. In the Trimmers Rock occurrences, furrow casts are washboard-like corrugations less than ¼ inch in width, usually less than 1 inch in length, and with relief less than 1/10 inch. Individual furrows are remarkably parallel, linear, and some display a tiny median groove.

Winterer notes that furrow casts of the Normandy occurrences are found normal to and on the down-current flank of ripple-crests. The Trimmers

FIGURE 40. View upward at graywacke sale. Siltstone Unit 3 at Shamokin Dam, Snyder County, Pennsylvania. Graave casts with chevran; current from upper right. Prad cast at right center. Hammer far scale.

WIDTH (INCHES)	LENGTH (INCHES) 1	2	3	4	5	6	7	8	9	10	11	14	18	24	26	TOTALS
1/16	12	16	3	5	1	1	1	1	1							41
1/8	8	7	6	7	3	1	1					1				34
1/4	1	7	3	3	2	2	1			1						20
3/8		1		1		1	1									4
1/2	1		1				1	1	1			1				6
3/4								1	1							2
1					1						1			1		3
1 1/2													1			1
2															1	1
TOTAL	22	31	13	16	7	5	5	3	3	1	1	2	1	1	1	112

TABLE 2. *Positive correlation ($r = .720$, which is significant at the .1% level) of groove-cast length and width. Each row and each column shows a poor approximation to a normal distribution.*

Rock furrows are concentrated in broad flat ripple troughs and on unrippled tops where they completely cover small areas.

At one locality (unit 8, Port Jervis section) linear bands in furrow structure occur on the bed top and are parallel to groove casts on the sole of the same bed. In unit 22 at Port Jervis furrows are constantly oriented at about 95° to well-defined ripple mark (Figure 41). Because of these associations there can be little doubt that the orientation of furrow casts is parallel to paleocurrent direction.

CONGLOMERATE

As considered here, conglomerate excludes the very common rocks which contain abundant fragments of semi-consolidated shale and the graywackes partially made up of fossil-fragment layers, both of which are discussed elsewhere. Conglomerate is limited in occurrence to the upper part of the Trimmers Rock in the Bowmanstown-Schuylkill Haven region. This rock type is best developed in Conglomeratic Sandstone Unit 5b at New Ringgold, but is also present in that unit at Schuylkill Haven. Other conglomerates occur in the strata called Parkhead Sandstone in Maryland. The Saxton Conglomerate and other less-continuous bodies (Butts, 1945, p. 12) are well developed in the Huntingdon-Hollidaysburg area.

The matrix material of most conglomerates of the Trimmers Rock is subgraywacke sandstone, and subgraywackes without clasts are generally interbedded with conglomerates. Most conglomerates of the Trimmers Rock occur as pods and stringers of clasts along bedding planes, but a few are massive rocks with dispersed fragments. In color, most conglomerate is light gray to nearly white, probably because of the high quartz content of the matrix sandstone. Euhedral pyrite is abundant in both subgraywacke and conglomerate.

Clasts in conglomerate constitute up to about 30% of the rock and consist for the most part of white vein quartz. A few pebbles of black chert, brownish-gray siltstone, and reddish-colored silica rock, possibly jasper, were found in conglomerates at New Ringgold. Clast size in conglomerate ranges from granules to cobbles. Pebbles are most common, granules abundant, and cobbles rare. The largest clast observed measured 3 inches in diameter and was found in unit 17 at New Ringgold.

Quartz clasts in conglomerate are sub-rounded to well rounded. Subangular clasts are very rare, and no angular fragments were found. Shape of clasts, however, is highly varied. Some western occurrences contain white vein quartz of very flat, almost tabular, shapes. These flat-pebble clasts constitute as much as 70% of the clasts present in such rocks.

Because most conglomerates occur as bodies which are lenticular in outcrop, their use in lithic correlation seems limited. Sandstone Unit 5b, which is present in three southern sections, contains conglomerates at Schuylkill Haven and New Ringgold, but not at Bowmanstown.

FIGURE 41. Ripple marks with furrow casts in the troughs. Current from top to bottom. Siltstone Unit 3 at Millrift, Pike County, Pennsylvania in the Port Jervis section. Twenty-five cent coin for scale.

COLOR

Color is considerably varied in the Trimmers Rock Member of the Fort Littleton Formation. The dominant colors are intermediate shades of gray, but the Trimmers Rock also includes strata of such diverse colors as yellow, red-brown, and black. All determinations of color in this study are based on the Rock Color Chart prepared by the Rock Color Chart Committee (Goddard and others, 1951).

Color due to variation in the nature and extent of all post-depositional changes is so great that the color designation of any unit, even single beds, may include several of the color "points" of the Color Chart, and it is impractical to include four, five, or six color designations in rock-description tables (Appendix A). For this reason, colors are grouped into commonly associated suites. Preliminary examination of a section near Amity Hall in Perry County established that similar colors occur together; these associated colors are therefore grouped into 11 suites. The suites recognized in this early work were afterward successfully utilized in all sections described.

The informally named suites with their respective letter designations as used in Appendix A consist of the following colors:

A. Blacks. N 1, N 2.
B. Dark grays. N3, 5 B 3/1.
C. Medium grays. N4, N 5, 5 B 5/1, 5 B 4/1, 10 YR 4/2.
D. Light grays. N 6, N 7, 5 Y 5/2, 5 GY 6/1.
E. Very light grays. N 8, 10 Y 6/2.
F. Dark olive greens. 10 Y 5/4, 10 Y 6/6, 5 GY 5/2, 5 GY 3/2.
G. Light olive greens. 5 Y 6/4, 10 Y 7/4, 10 GY 7/2.
H. Dark browns. 5 Y 4/4, 5 YR 4/1, 5 YR 5/2, 5 YR 4/4, 10 YR 4/2.
I. Light browns. 5 YR 7/2, 5 YR 6/4, 5 YR 6/2, 10 YR 6/6.
J. Reds. 10 R 5/4, 10 R 4/6, 5 YR 3/4, 5 RP 4/2.
K. Yellows. 5 Y 8/4, 5 Y 7/6.

The primary purpose of this method is to define the color of a thin rock unit from variation detected in freshly broken samples. Accordingly, many rock-unit descriptions contain more than one designation for color. In the color column of Appendix A, the dominant suite is listed first.

Color is a very significant aspect of the Trimmers Rock. The contact between the Fort Littleton Formation and the Catskill Formation is based on color, the lowest strata of distinctive grayish-red colors being designated Catskill. (Hoskins and others, 1963, p. 161-162.) These colors are hues of red in the range 5 R 4/2 to 10 R 4/2. The writer has suggested (Frakes, 1961, p. 123) that color of the basal Catskill is the result of redeposition of red sediment, perhaps derived from originally red rocks.

Other reddish colors, shades of red and purple listed in suite J above, occur locally in shales of the Trimmers Rock. These reddish colors appear to re-

sult from concentrated hematite staining. Wide-spread staining in thin section is associated with reddish color in outcrop, but these colors have little stratigraphic or mapping value.

These red and purple colors are often associated with various shades of green. Boundaries between suite J colors and green colors are irregular in configuration and gradational in most cases, and small patches of green colors locally occur within solid reddish shales.

Olive-green colors comprise suites F and G above. The cause of green coloration is not definitely known, but it may well be related to the abundance of chlorite in the rock. As far as can be determined, chlorite occurs as both detrital and secondary replacement of clay minerals in strata of the Trimmers Rock. Much more detailed study is needed to ascertain the origin of chlorite in these rocks.

Gray coloration, representing the absence or minor presence of other colors cannot be attributed to any one factor. Relative abundance of fine-grained matrix cannot fully explain variation in grayness because all shades of gray are present in all rock types, from shale to medium-grained sandstone. However, a statistical association may exist between amount of matrix and shade of grayness.

Brown colors are predominantly the result of surficial weathering of light- and medium-gray rocks in the Trimmers Rock. The shades of brown and yellow commonly seen delineating liesegang bands possibly result from limonitization of iron-bearing minerals in siltstones and sandstones.

In the Trimmers Rock, black colors occur only locally in shale. Many black shales of the Trimmers Rock and the Burket Member of the Rush Formation contain abundant euhedral pyrite, suggesting that chemical conditions during or shortly following deposition were suitable for precipitation of sulfides. Locally, black shales weather to a characteristic light-gray color and rarely to shades of yellow.

STRATIFICATION

Graded Bedding

General

In gross aspect the Trimmers Rock Member of the Fort Littleton Formation resembles other rocks which have been ascribed to deposition from turbidity currents. Such units include the Martinsburg Formation (McBride, 1962) of the Appalachian region and other rocks of widely different age and distribution. McIver (1960) applied the concept of turbidity currents to part of the "Portage" and "Chemung" of the Appalachians in a study which includes the same rocks examined in the present study.

Kuenen and Migliorini (1950) demonstrated that sediments deposited from continually decelerating experimental turbidity currents are vertically and

laterally graded. Vertical size-grading, although not necessarily restricted in occurrence to rocks deposited from turbidity currents, is a requisite characteristic for identification of turbidity current deposits. The presence of size-grading is obvious in Type II beds of the Trimmers Rock, which show an upper gradation to shale, but the predominant Type I beds are fine-grained graywackes, and their structure is determined only with difficulty in the field. A detailed study was therefore made to determine the size-distribution of quartz grains through both Type I and Type II beds.

Methods

Six samples were selected from five measured sections. All samples were taken from thin beds so that one thin-section normal to bedding essentially spanned the stratum. Thin-section AH-102 is cut through a single Type II bed. Of the remaining five thin-sections of Type I beds, one, AH-101, is a composite bed consisting of three distinct sedimentation units. The basal unit of this section was analyzed and is included in the summary. The remaining four samples, P-101, NR-56, SD-72, and SH-73, are cut through single Type I beds.

The method of analysis was designed to include the full thickness of the bed so that grain size distribution could be determined for the entire sedimentation unit. A series of traverses was made parallel to bedding; traverses were numbered beginning with traverse 1 at the bed base. Measurements were made of the long dimension of all quartz grains in contact with the traverse line across the thin-section. The smallest grains measured had a length of .0165 mm because discrimination of grain boundaries was vague below this limit. After grain counting and application of the factor allowing for random slicing of spherical grains in thin-section (Krumbein, 1935) the data were tabulated by size (Appendix C).

Interpretation

The data are summarized in Appendix C. Examination of the tables reveals that size grading of quartz is present in all samples. In each case, frequencies of the smaller size classes increase toward the bed top, and frequencies of the larger size classes decrease correspondingly. Histograms depicting the size distributions in successive traverses disclose the relationships more clearly (Figures 42, 43, and 44). Statistical graded bedding is concluded to be a common characteristic of the Trimmers Rock.

Variation in mean size with position in the bed is shown in the histograms. Mean size decreases with slight irregularity from a maximum value in the lowest or next-lowest traverse to a minimum at the top of the bed. This grading of mean size is accomplished by systematic variation in frequency of the individual size classes. The table shows that successively smaller size classes attain their maximum percentage concentrations in successively higher

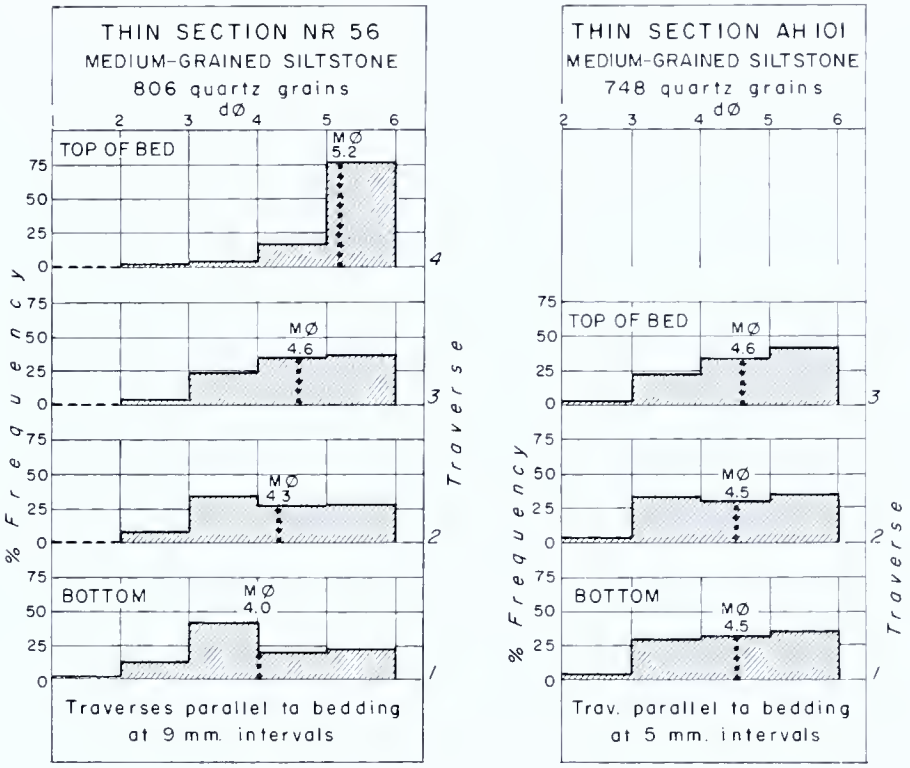

FIGURE 42. Size analyses of two thin sections.

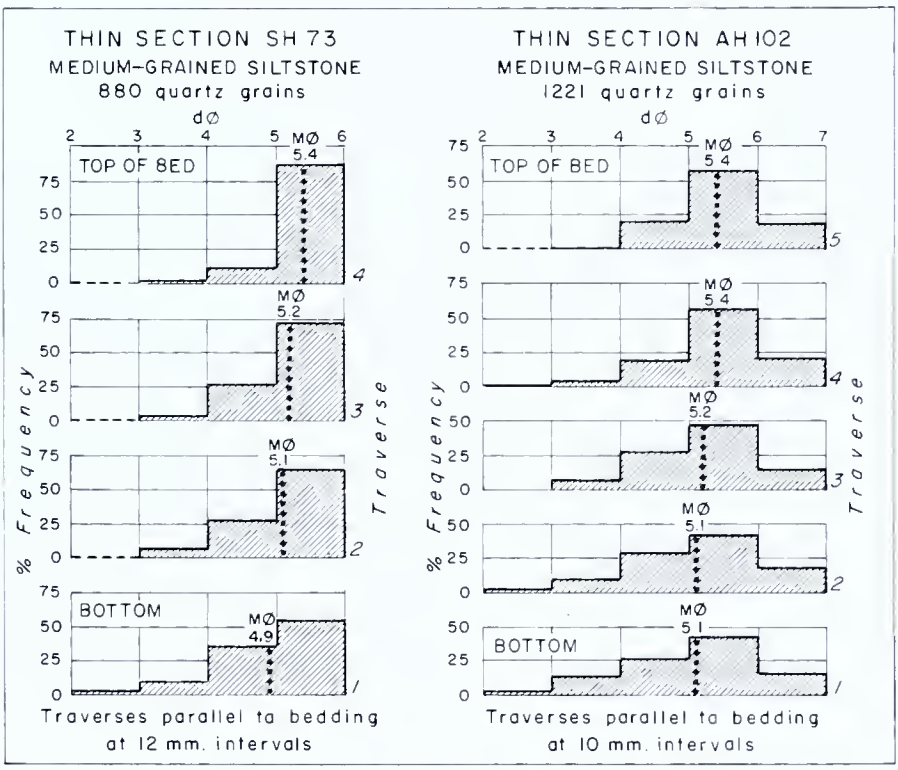

FIGURE 43. Size analyses of two thin sections.

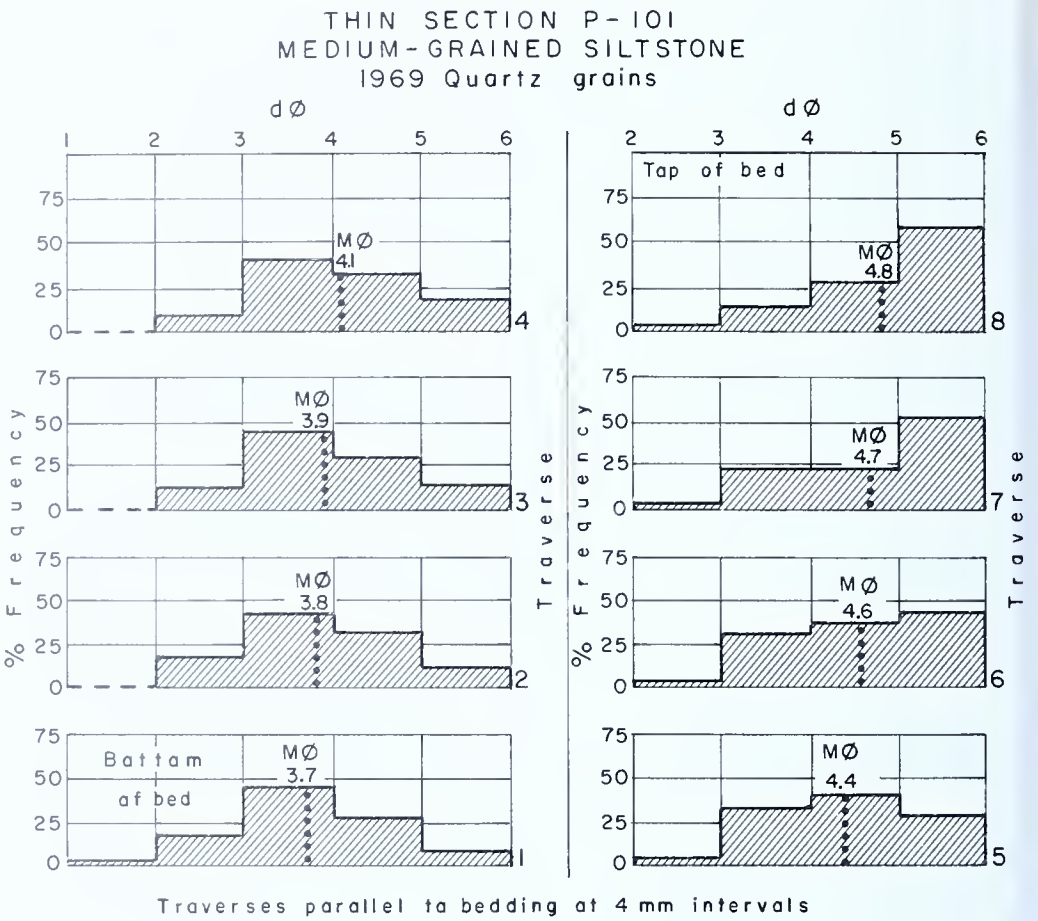

FIGURE 44. Size analysis of a thin section.

traverses. There is a corresponding *decrease* in percentage concentration of successively *larger* size classes in successively higher traverses (Frakes 1962a, 1962b).

Standard deviation (Krumbein 1936, p. 39-40) varies with mean size as shown in Figure 45. A strong positive correlation is indicated by the distribution of these values. With increasing mean size, standard deviation (σ_ϕ) becomes larger and sorting therefore poorer. Toward the right side of the diagram, approximate best-fit lines for individual beds are more steeply inclined than are those to the left. This relationship might be taken to mean that sorting varies almost independently of mean size when mean size is small, but it is more likely that steepness of the plot at the right is related to the lower limit of grain-size observation, about 6.3 Φ.

Distribution of mean size in these rocks suggests that some factor common to all caused coarse grains to be concentrated in the lower portions of the bed and fine grains in the upper. This factor must be a characteristic of the transporting agent because the results are all internal to the bed, and no breaks in sedimentation are visible in the rocks examined. Continuously decreasing kinetic energy due to loss of velocity at the site of deposition seems to be the only feasible explanation for size grading.

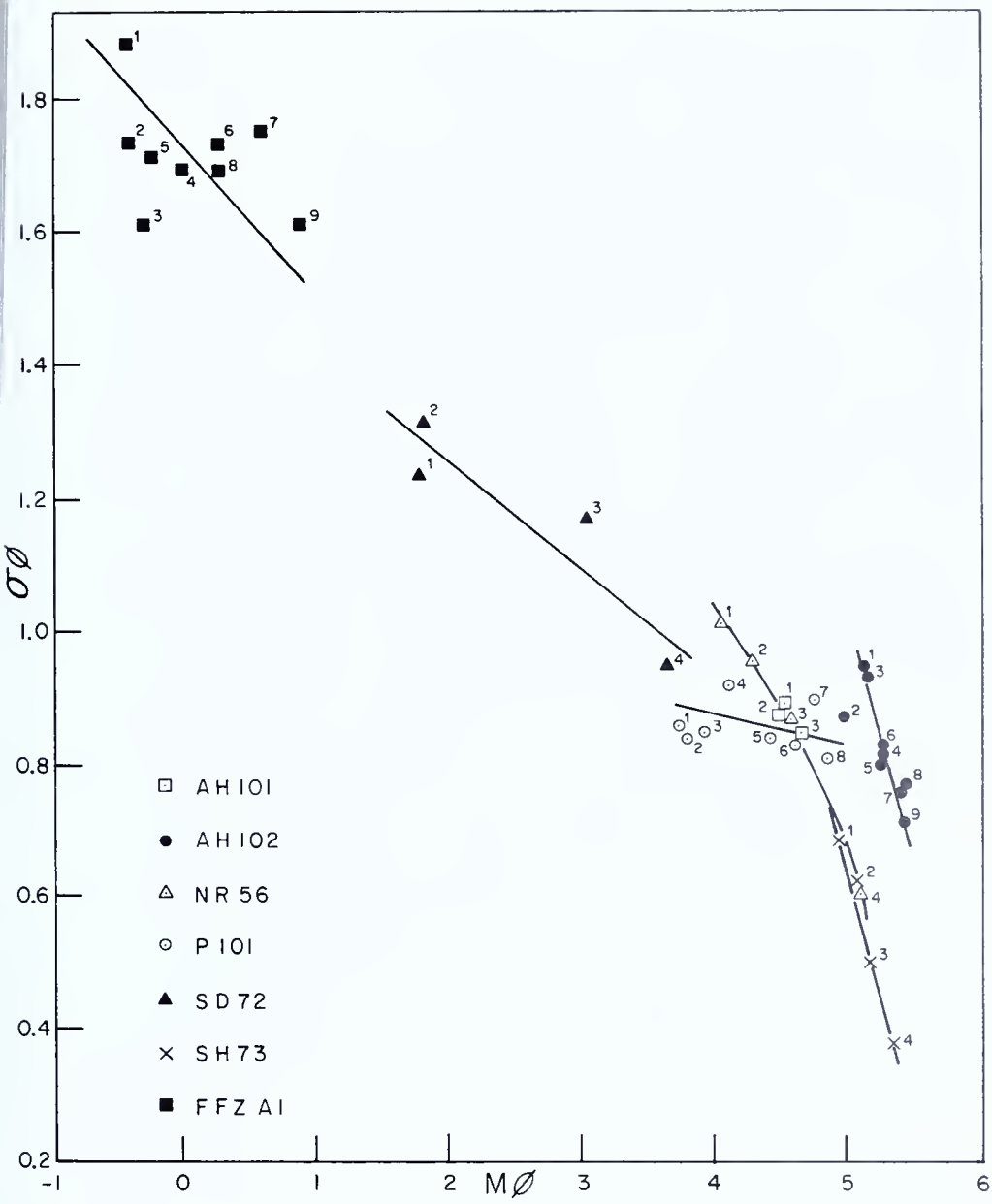

FIGURE 45. Graph of mean size and standard deviation data from six thin sections and one polished section (FFZA1).

Bed Thickness

General

An attempt was made to determine geographic and stratigraphic variation of bed thickness by estimation methods during measurement of the sections. However, these data are not reproducible in the field, and this aspect of the Trimmers Rock remains unevaluated.

A measure of bed thickness variability in the Trimmers Rock can be gained from detailed measurements of 61 feet of section at Girtys Notch. These strata encompass measurement units 112 to 120 at the top of Siltstone Unit 5. Type I, Type II, and shale beds were measured to ¼″ accuracy.

Frequency Distributions

Bed thicknesses for the three rock types are summarized in Table 3 and Figure 46. In these arithmetic-frequency distributions it is obvious that all three plots are skewed to the right; there are a larger number of thin beds. Type I beds range in thickness from ¼″ to 16″ and show wide dispersion. Type II beds show narrow dispersion ranging from ¼″ to 5″. Shales show the greatest range, ¼″ to 20″, but values are strongly clustered at the left. The strong skewness of these plots assures that bed thickness cannot be considered as normally distributed.

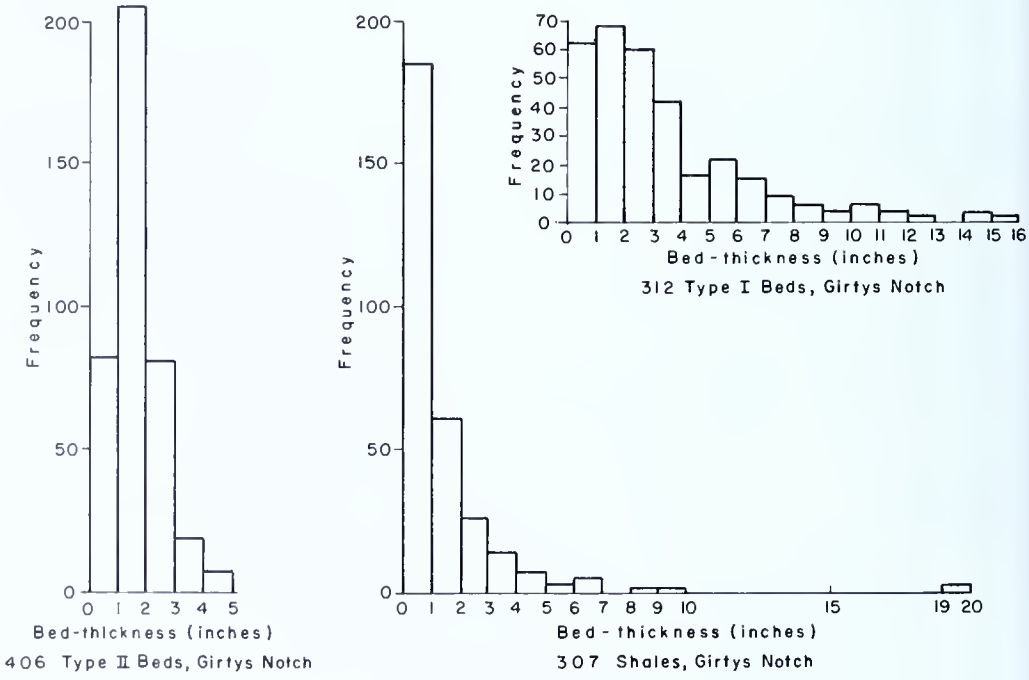

FIGURE 46. Histograms of bed-thickness frequency distributions.

Theta scale		(−3)–(−2)	(−2)–(−1)	(−1)–0	0–1	1–2	2–3	3–4	4–5	TOTALS
Inches		<¼	¼–½	½–1	1–2	2–4	4–8	8–16	16-32	
Type I	#	15	11	35	68	101	62	20	0	312
Beds	%	4.8	3.5	11.2	21.8	32.4	19.8	6.4	0	99.9
Type II	#	6	12	66	211	102	9	0	0	406
Beds	%	1.5	2.9	16.3	52.0	25.1	2.2	0	0	100.0
Shales	#	53	45	87	62	42	15	2	1	307
	%	17.3	14.7	28.3	20.2	13.6	4.9	.7	.3	100.0
TOTALS	#	74	68	188	341	245	86	22	1	1025
	%	7.2	6.6	18.3	33.3	23.9	8.4	2.1	.1	99.9

TABLE 3. *Bed thickness by rock type and theta classes, detailed section at Girtys Notch.*

Pettijohn (1949, p. 135) inferred that thicknesses of graded beds and varves conform to log-normal probabilities because such data plot as straight lines on log probability paper. The approximation of bed thickness to the log-normal has been shown by Schwarzacher (1953), Bokman (1953), Potter and Siever (1955), Nederlof (1959) and Atkinson (1962) among others. The transformation of data to log-normally defined classes may be accomplished by the use of the theta scale (Bokman, 1957). Kolmogorov (1949) explained the log-normal frequency distribution of bed thickness by preferential erosion of thin beds in an originally arithmetical-normal distribution.

Bed thicknesses obtained in the present study are plotted on log-probability paper in Figure 47. Although each plot, including one for the total 1025 beds, approximates a straight line there is a noticeable tendency for the lines to be concave downward. Downward concavity is particularly marked in the plot of Type II beds. Best-fit lines drawn for any set of data would lie to the left of the concave plot at both extremities. The number of thin beds and thick beds is thus in excess of what would be expected if bed thickness conformed to the log-normal law.

Use is made of the log-normal transformation in most studies to allow treatment of the data by various parametric statistical methods. Justification of these methods rests on the approximation to a straight line on log probability paper. Whether the data actually do plot as a straight line is usually decided subjectively. This decision is greatly influenced by such factors as scale of the plot and the number of data-points employed.

The frequency distributions of bed thickness in the Trimmers Rock are compared with log-normal frequency distributions of the same sample size, mean, and standard deviation in Figure 48. Differences between observed

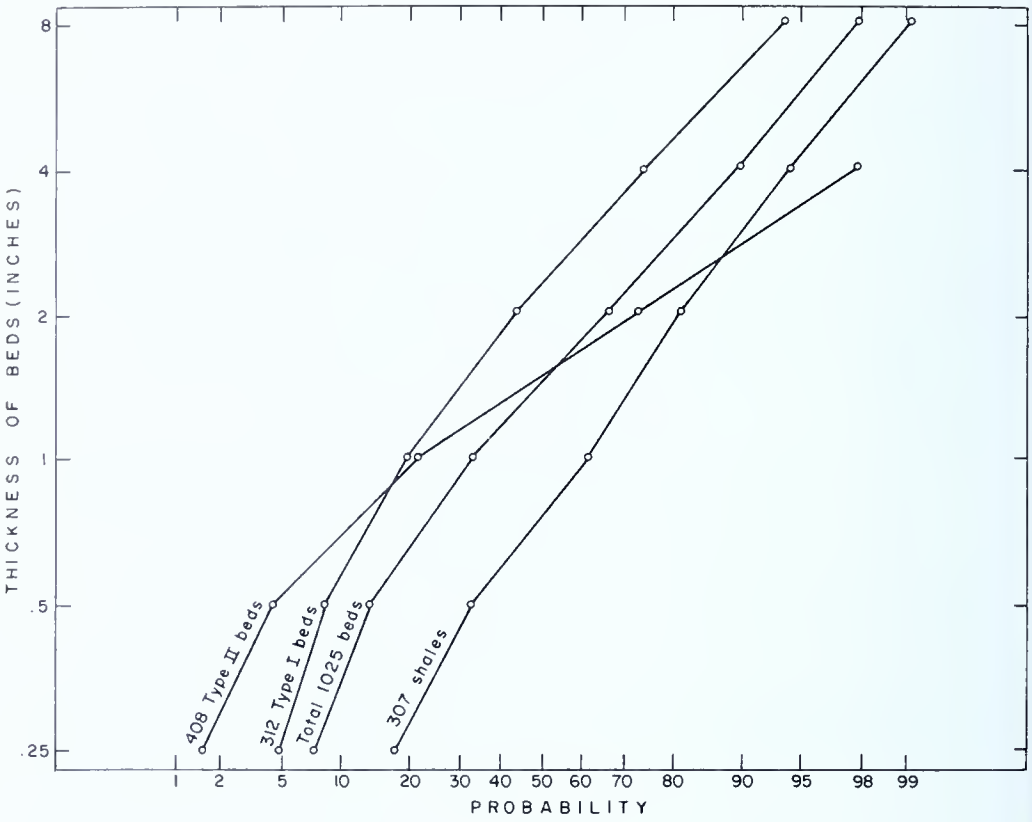

FIGURE 47. Log-probability plot of bed thickness frequency distributions at Girtys Notch.

and theoretical frequencies in each theta size class are substantial, particularly for Type I beds and shales. Chi-square tests show that the difference is significant at the .005 level for all three distributions. The probability that the observed sample of Type I beds could have been drawn from the same population as the theoretical sample is less than one in two hundred; the same probability applies to Type II beds and shales.

Frequency distributions of bed thickness in the Trimmers Rock do not follow the log-normal probability law although they approximate straight lines on log probability paper. Additionally, the skewness of the distributions in Figure 48 cannot be explained by removal of the thinner beds through erosional processes as postulated by Kolmogorov because there is a *surplus* of observed thin beds over the theoretical log-normal distribution. The effect of slight erosion would be to completely remove relatively thin beds and only a portion of thicker beds. Because thin beds are so abundant it was considered possible that the observed frequencies might result from erosion of the thin beds of an original Poisson distribution. But in a comparison

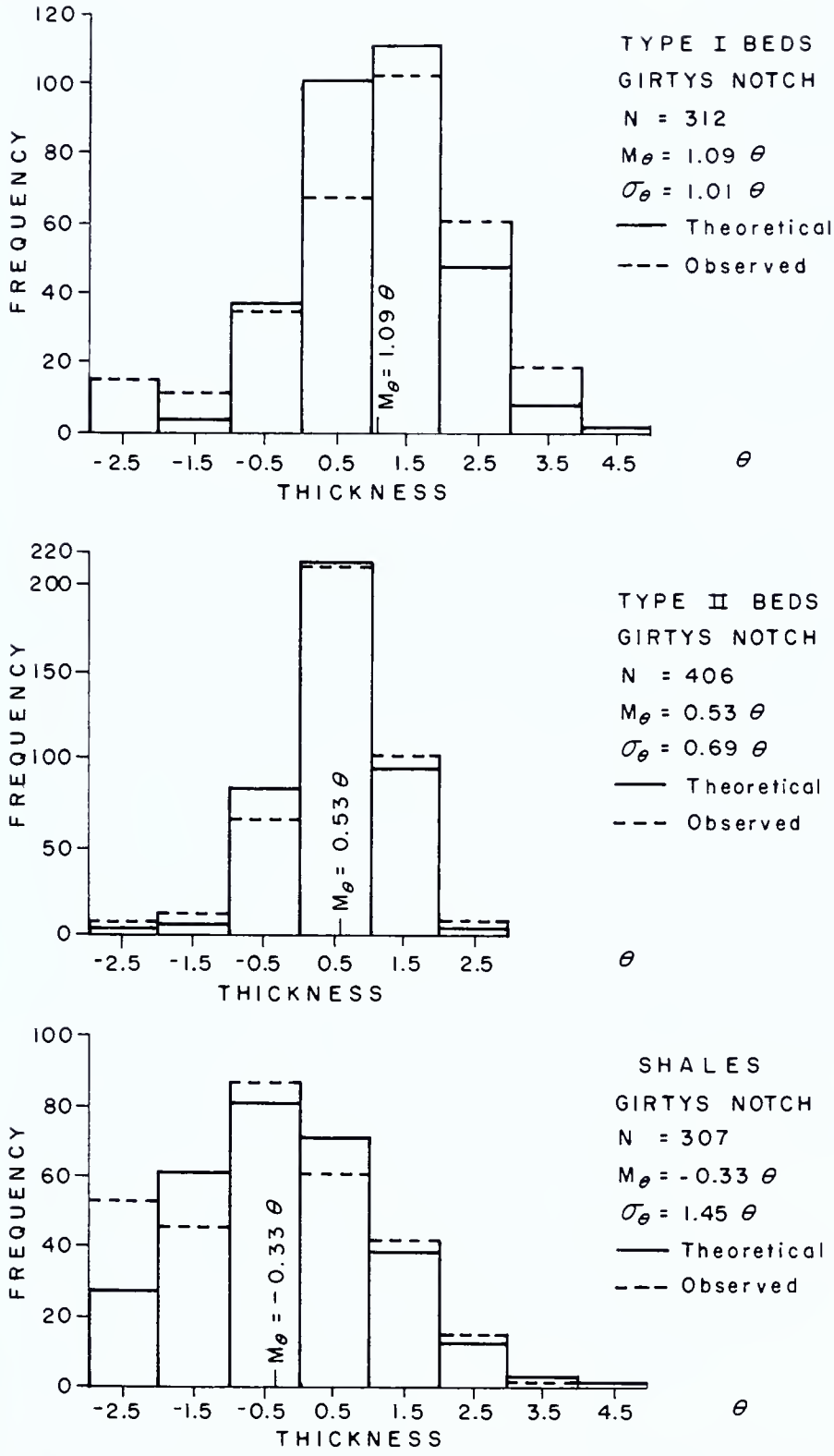

FIGURE 48. Comparison of observed and expected log-normal frequency distributions of bed thickness.

of Type I beds with a Poisson distribution of the same mean and sample size, Chi-square is not significant at the .005 level, and again observed thin beds exceed the theoretical ones. The superabundance of thin beds indicates a strongly skewed original distribution, perhaps conforming to the binomial law.

Frequency distributions of bed thickness may eventually prove to be environmentally significant. In the present study, the frequency distributions suggest that bed thickness conformed to the binomial law before erosion by currents. Perhaps bed thickness in low-engery, noneroding environments is controlled by the same law, in which case the original distribution might be preserved. On the other hand, low-energy environments may produce log-normal or Poisson bed thickness distributions.

Lateral Extent

The lateral extent of a bed is of particular interest for purposes of prediction. Given the thicknesses of a group of beds at a geographic point, it would be desirable to know how thick the individual beds might be at a certain distance normal to the sedimentary strike, and thus whether they might constitute a potential petroleum reservoir, for example.

This problem may be attacked by either of two methods, both of which must assume that thickness change follows a fixed law. First, a gross indication of lateral bed-thickness variation is provided by isopach maps of stratigraphic units. The disadvantages of this method include the influences of tectonic deformation on unit thickness and the generally imperfectly known stratigraphic relationships of the unit to adjoining rocks. Second, lateral variation may be determined over a relatively short distance in a particular outcrop, thus establishing an index of thickness change. The most formidable disadvantage of this method is that thickness changes over a short distance are generally so small that they may be obscured by local compaction and tectonic effects. This latter method is preferred, however, because a large sample will tend to minimize the local effects.

A portion of the section studied in detail at Girtys Notch is exposed over an avcrage bed length of 163 feet in a high north-south cut (Figure 49). This orientation is approximately normal to the depositional strike of Type I beds and parallel to that of Type II beds. For purposes of this discussion the algebraic sign of thickness change is positive if the bed is thicker at the base of the cut (south) and negative if the bed is thicker at the top of the cut (north). Several beds were visibly correlated from the base to the top and the majority were correlated by homotaxis; beds not correlated are assumed to wedge out (Figure 49). Two bodies of disturbed bedding at the base of the cut and their correlative beds at the top are not considered in the discussion. The data are summarized in Table 4.

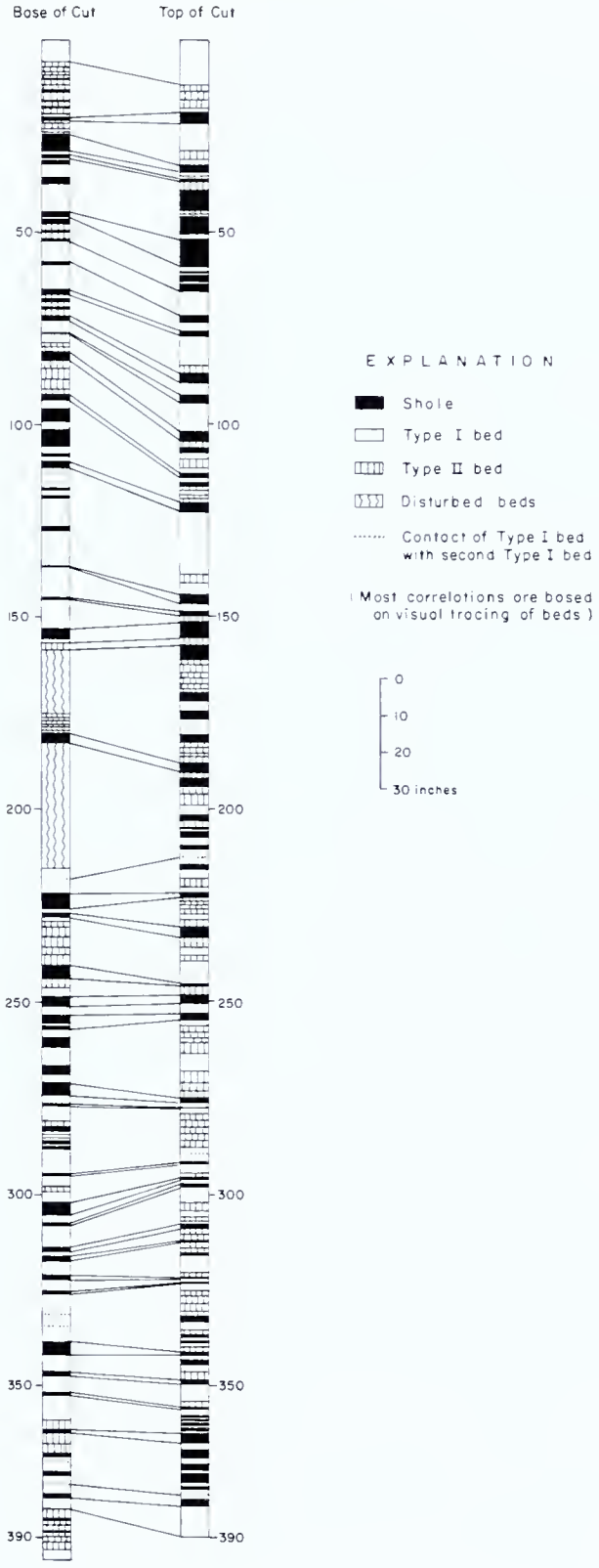

FIGURE 49. Lithologic variation at Girtys Notch.

ROCK TYPE	TOTAL BEDS #	POSITION IN CUT	#	TOTAL THICKNESS	CORRELATED BEDS #	% OF TOTAL BEDS	THICKNESS	% OF TOTAL THICKNESS	CHANGE, BASE TO TOP	AVG. CHANGE IN 163 FEET	INDEX AVG. CHANGE IN 100 FEET
TYPE I BEDS	76	BASE	58	189.00	42	56	162.00	83	−27.00	−.64	−.39
		TOP	60	172.75			135.00				
TYPE II BEDS	77	BASE	38	68.75	18	23	26.00	34	+1.25	+.07	+.04
		TOP	57	88.50			27.25				
SHALES	71	BASE	58	74.75	41	58	56.50	81	+18.00	+.44	+.27
		TOP	54	86.00			74.50				

TABLE 4. *Summary of data on bed thickness from base and top of cut at Girtys Notch. All thickness data in inches.*

Type I Beds

Seventy-six Type I beds occur in the section. Of these, 42 or 56% with a mean thickness of 3.0 inches, are correlated from the base to the top of the cut. However, the correlated beds constitute 83% of the thickness of all Type I beds, so that the Type I beds which wedge out are relatively thin, in fact averaging less than one inch. The average change in thickness of correlated beds over 163 feet from the base to the top of the cut is −.64 inches, and the index of thickness change calculated for 100 feet along the beds is therefore −.39 inches.

Sixteen Type I beds terminate to the north and 18 wedge out to the south. The terminations of thin beds are probably the result of deposition from a waning current on an uneven floor.

Type II Beds

There are 77 Type II beds in the section and 18 or 23% are correlated from the base of the cut to the top (Table 4). The mean bed thickness of correlated Type II beds is 1.7 inches. The correlated beds constitute only 34% of the total thickness of Type II beds and noncorrelated beds are comparable in thickness. For 163 feet along the bed the average change in thickness of correlated beds is negligible, being only +.07 inches. The index of thickness change is also small, +.04 inches.

Thirty-four Type II beds wedge out to the south and only 15 to the north. The asymmetry suggests that Type II beds were preferentially deposited at the north end of the cut, a suggestion which is strengthened by the low percentage of correlated beds and by current direction data. The low index for Type II beds might be considered typical for most turbidity-current deposits, which have often been referred to as exceedingly planar.

Shales

A total of 71 shale beds occur in the section, of which 41 or 58% are correlated (Table 4). Correlated beds have a mean thickness of 1.4 inches, and their total thickness constitutes 81% of all shales present. Shales are similar to Type I beds in that noncorrelated beds are relatively thin, with a mean thickness of less than one inch. Seventeen shales apparently wedge out to the north and 13 to the south.

For 163 feet along the bed, the average change in thickness of correlated shales is +.44 inches. The index of thickness change is calculated to be +.27, somewhat less than that for Type I beds but much greater than the index for Type II beds. This relationship may have depositional significance, but perhaps shale thicknesses are only more strongly affected by compaction and tectonic deformation than are Type II beds.

PALEONTOLOGY

GENERAL

The study of fossils in the Upper Devonian rocks of Pennsylvania and adjacent states is the subject of a voluminous literature spanning more than a century of research. In fact, this region is a classic area of Devonian biostratigraphy. No attempt was made in this study to determine the lateral or vertical distribution of the various types of fossils. In general, however, the abundance of many marine brachiopods, pelecypods, and gastropods, among others demonstrates that the Trimmers Rock was deposited in a marine environment (Willard, 1939, p. 235-238).

TRACE FOSSILS

Description

The term trace fossil refers to structures resulting from animal activity essentially at the time of deposition and includes such varied features as tracks, burrows, and feeding marks (see Häntzschel, 1962, p. W177-W183). In recent work, Seilacher (1962) discussed in detail methods of distinguishing pre- and post-depositional trace fossils.

Trace fossils are abundant in the Trimmers Rock Member of the Fort Littleton Formation where they are present as protuberances on graywacke soles. Their occurrence is noted for a majority of the measured units in Appendix A.

Generally, trace fossils in the Trimmers Rock are of two types: 1) linear forms which essentially parallel the bedding plane; and 2) equant protuberances which intersect the bedding plane at a large angle. Trace fossils parallel to the bedding plane are elongate in one direction, having a maximum observed length of about 6 inches. Most, however, are two to three inches long, average about $\frac{1}{8}$ inch wide, and fade into the bedding plane at the extremities. Relief is variable but seldom exceeds $\frac{1}{4}$ inch and averages about $\frac{1}{8}$ inch. In plan view most bed-parallel trace fossils are linear, but some show irregularly curved and recurved outlines. The genus *Planolites* is the most common form. Varieties superficially resembling the genera *Granularia* and *Eophyton* are common. *Eophyton* is listed as a questionable "fossil" possibly of inorganic origin by Häntzschel (1962, p. 234). *Pteridichnites biseriatus* Clarke and Swartz (1913, p. 545-546), described from the Upper Devonian of Maryland, was not recognized in the course of this study. One occurrence of a form similar to *Oldhamnia* was observed low in the section at Port Jervis.

Trace fossils which lie at some angle to the bedding plane are abundant and generally occur in association with bed-parallel types. In fact, a com-

plete gradation exists from equant knobs on the graywacke sole to elongate linear traces. It seems probable, therefore, that most trace fossils represent burrows or feedingways made by animals which moved at various angles to the surface of sedimentation.

Origin

Two possible explanations exist for trace fossils truncated by inorganic sole marks: 1) trace fossils are casts of marks left by animals which moved about on the surface of deposition; or 2) trace fossils are partially-eroded casts of burrows made by organisms which moved within the muddy substratum. The necessary condition that such trace fossils originated before the overlying bed was deposited (pre-depositional) is satisfied by both explanations.

One line of evidence strongly suggests that the first explanation is invalid. The semi-cylindrical shape of most organic casts indicates that the animal must have moved at least partially *through* the substratum rather than above it.

Several other lines of evidence, while not conclusive, strongly favor the generalization that pre-depositional trace-fossil casts instead represent infilling of partially eroded burrows. The nature of the sediment-water interface during deposition of these strata is not known, but the great dominance of shale and siltstone indicates that suspended and loosely consolidated material may have formed a relatively thick layer above the more solid substratum. Any trace fossil preserved from this type of environment would be, by necessity, a burrow rather than a track. The independent evidence of erosion displayed by many graywacke beds in the Trimmers Rock, as exemplified by truncated current-lamination, is perhaps the strongest indication that erosion has played a role in formation of trace-fossil casts. An erosive current of comparatively small force would be capable of removing a layer of loosely-consolidated silt- and clay-sized particles. Because the strata of the Trimmers Rock are consistently planar the current must have been effective in eroding sheet-like masses, as suggested by Seilacher (1962, p. 232) for flysch rocks of Spain.

Isolated casts of equant shape and considerable relief are most easily explained as infilled burrows inclined to bedding at a high angle. Linear casts, on the other hand, are characterized by imperceptible merging with the sole, particularly at the extremities. Erosion by a current moving along the bottom might best explain this fading.

The most reliable criterion for recognition of post-depositional trace-fossils (formed after deposition of the overlying bed) is penetration of the graywacke sole by the organic structure. In rare examples the trace fossil occurs as a linear *depression* on the graywacke sole, and the marginal walls of the structure are steeply inclined or vertical. It is difficult to imagine how the mold

for this structure could have formed prior to deposition of the superjacent graywacke because any water movement would have destroyed the delicate steep-sided ridge. Formation of the structure by an organism burrowing along the mud-sand interface after deposition of the overlying bed appears to be the only logical explanation.

For the examples where relative time of origin is established, pre-depositional forms are considerably more abundant than post-depositional ones. It is indicated, therefore, that mud burrowers represented a very common form of life during deposition of these strata. Because post-depositional trace-fossils are physically similar to pre-depositional forms it is considered likely that many post-depositional structures were formed by these burrowing organisms trapped beneath the accumulating graywacke bed. As such they are termed entrapment burrows (Kuenen, 1957, p. 253, Seilacher, 1962, p. 229).

McAlester (1960) notes that the pelecypod genera *Nuculoidea* and "*Nuculana*" of the New York Upper Devonian may have been deposit-feeders, in which case some burrows may have been formed by these animals. Trace fossils have often been ascribed to the burrowing activity of worms (Fuchs, 1895; Richter, 1927; Seilacher, 1962), and this interpretation is applied to the forms which occur in the Trimmers Rock. Trace fossils have been described from a wide variety of depositional environments in both modern sediments and ancient rocks (see Häntzschel, 1962, p. W178), but widespread restriction of genera to specific environments has not yet been accomplished. Perhaps the most significant paleoecologic implication of the abundant worm burrows in the Trimmers Rock strata is that bottom sediments were sufficiently oxygenated to allow organisms to exist. Further interpretations would not be justified by the evidence available.

FOSSIL-FRAGMENT ZONES

The Trimmers Rock Member of the Fort Littleton Formation, in contrast with many sedimentary sequences, contains fossils which are concentrated in graywacke beds rather than in shale. Fossils in shale are rare and widely scattered; their occurrence is noted in Appendix A. Fossils in the graywackes occur in abundant zones or layers at the base of the bed.

Fossils in such zones are generally fragmentary, but a few layers were observed in which large valves of brachiopods and pelecypods and complete gastropod shells constitute the bulk of the zone. The most common fossils present in fossil-fragment zones are various types of bryozoans and broken crinoid columnals (Figure 50).

Fossil-fragment layers constitute the basal portion of the graywacke bed but are not as continuous laterally as the bed itself. Many fragmental layers wedge out laterally in barren graywacke, and in most such cases there is a slight rising of the layer in the bed as it terminates. In a few instances the fossil-fragment zone constitutes the entire bed, but generally the zone is from

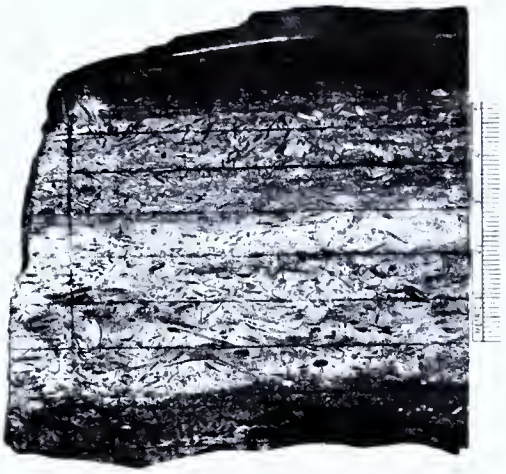

FIGURE 50. Cut surface of fossil-fragment layer showing traverse lines for analysis of graded bedding. Fossil material consists of fragmental bryozoans, crinoid columnals, and broken brachiopod and pelecypod valves. Large shale chip at base and smaller ones scattered throughout the sample. Scale in centimeters.

an inch to several inches thick and makes up less than half of the bed. The thickest fossil-fragment zone observed measures 14 inches at Nescopeck, Luzerne County while the thinnest, represented by a single layer of small fragments, are a fraction of an inch thick.

As shown by Frakes (1962a, 1962b), fossil-fragment zones are vertically graded with mean size decreasing steadily upward. In origin the layers are ascribed to the same process which causes graded bedding in barren graywackes. Currents carrying fossil debris deposited the fossil fragments early in the depositional phase, as is shown by the localization of the fragment zone at the base of the bed. Rapid energy loss in the current is suggested as the cause of deposition.

The fossil-fragment layer terminates by wedging as a body into the subjacent shale and the overlying graywacke; evidence of multiple interdigitation with either shale or graywacke is not observed. Frequent rising of the fragmental layer above the base of the graywacke bed is associated with marked thinning of the layer and slight thinning of the bed. These characteristics suggest that the fossil-fragment layer was deposited by a discrete current, and that the area of deposition of the layer was determined by the volume of fragmental material in the current.

The wedging out of the fossil-fragment zone is physically similar to wedge outs of sandstones in the Upper Miocene Modelo Formation of Southern California (Sullwold, 1961, p. 68). Absence of interfingering and erosional contacts along the boundaries of the fossil-fragment layer demonstrates that the layer and its enclosing graywacke were deposited as one sedimentation

unit independent of finer grained material accumulating beyond the wedge out. Sullwold (p. 64) has further suggested that turbidity-current deposits are characterized by abrupt wedge outs. The character of graded fossil-fragment zones in the Trimmers Rock indicates that graded beds wedge out from the bottom upward as one approaches the extremity. This feature may serve to distinguish rocks of turbidity-current origin from those of different origins.

Possibly the most significant paleontologic relationship in the Trimmers Rock is the general absence of fossils in shales and the abundance of broken forms in the graywackes. These characteristics suggest that most shells were transported by the currents which deposited the Trimmers Rock graywackes, but not by the water bodies which carried the sediment of the shales. The paucity of fossils in place suggests that few animals, other than those which left their traces as burrows, inhabited the depositional area. The implication is strong that fossils in the fragmental layers were moved by currents of high competence from areas in which conditions were more favorable for life, possibly from shallower water.

Paleontologic study of the Trimmers Rock must consider that fossil assemblages in the graywackes have been transported. A question of considerable importance is the distance of transport, but an estimate of this distance is not possible at present because undoubted source beds have not yet been located. Fossils in the fragment zones are likely to be reliable age indicators, but caution should be used in paleoecologic and biofacies studies. McAlester (1960), in a study of paleoecologic associations of New York Upper Devonian pelecypods, observed that mixing of several ecologic types locally occurs in similar fragmental layers.

DISTRIBUTION OF LITHOLOGIC AND PALEONTOLOGIC FEATURES

INTRODUCTION

In describing sections of the Trimmers Rock Member of the Fort Littleton Formation, several lithologic features were recognized as characteristic of the unit. Some, such as gross rock type, are highly persistent both laterally and vertically. Others, including landslide deposits, are restricted geographically and stratigraphically. A spectrum of variability might be anticipated to characterize the complete set of lithologic features of a stratigraphic unit because of the wide variability in extent and duration of the processes which form them. In many cases, however, the scale of observation and measurement prevents refined description and, hence, determination of variability of some features. This is exemplified in the present study by inability to detect the relatively small variations in grain size. Although all characteristics of

the rock may be significant, the worker must limit his observations to those data which might presumably answer his questions.

In the present study, observations were made on the types of features included in Appendix A; the regional and stratigraphic variation of these features is the subject of this section. The simplest type of observation is the presence or absence of a certain feature or attribute such as a particular rock type. The next higher level of observation is estimation of abundance of a feature. A third level of measurement is utilized in obtaining directional data, such as orientation of sedimentary structures.

Most data gathered by these methods are summarized in maps and stratigraphic diagrams constructed for the purpose of showing variability of lithologic features. These maps are most useful in inferring spatial and temporal distribution of processes responsible for the features observed and for delineating paleogeographic trends. A major salient in the Appalachian structure in this region makes construction of palinspastic maps almost impossible. As a result, all maps included herein are constructed on the present base.

DISTRIBUTION OF ROCK-TYPES

In general, the Trimmers Rock is characterized by shale, Type I beds, and, increasingly toward the west and northwest, Type II beds. Because they largely represent thin Type I beds, Type III beds are grouped with Type I beds in this discussion.

The data of Figures 51 through 55 were obtained by calculating the total thickness of each rock-type in Siltstone Units 3, 4, and 5 from the percentage estimates of the measurement units and expressing these values as fractions of the total thickness at each station. It is assumed that unmeasured strata in short covered intervals would not significantly change the values calculated in this way although most covered intervals likely contain high percentages of shale. Stations including long covered intervals are queried in the maps. These maps are thus similar to clastic-ratio maps.

Maps for informal rock- stratigraphic units other than 3, 4, and 5 were not constructed for a variety of reasons. First, all units above Siltstone Unit 5 are at least partially replaced laterally by Catskill strata or the Delaware River Flags, and therefore the value of isolith maps for these units is questionable. Second, lenticular units, such as Siltstone Unit 2, are sufficiently understood from the isopach maps so that analysis of rock type distribution is superfluous. Third, some units are measurable in less than half the sections examined because of a combination of faulting, covered intervals, lateral replacement, and lenticularity.

From consideration of these units together with their isopach maps (Figures 7, 8, and 9) several facts about rock-type distribution are apparent. First, the dominant trend of isoliths for Type I beds and conglomeratic sandstones

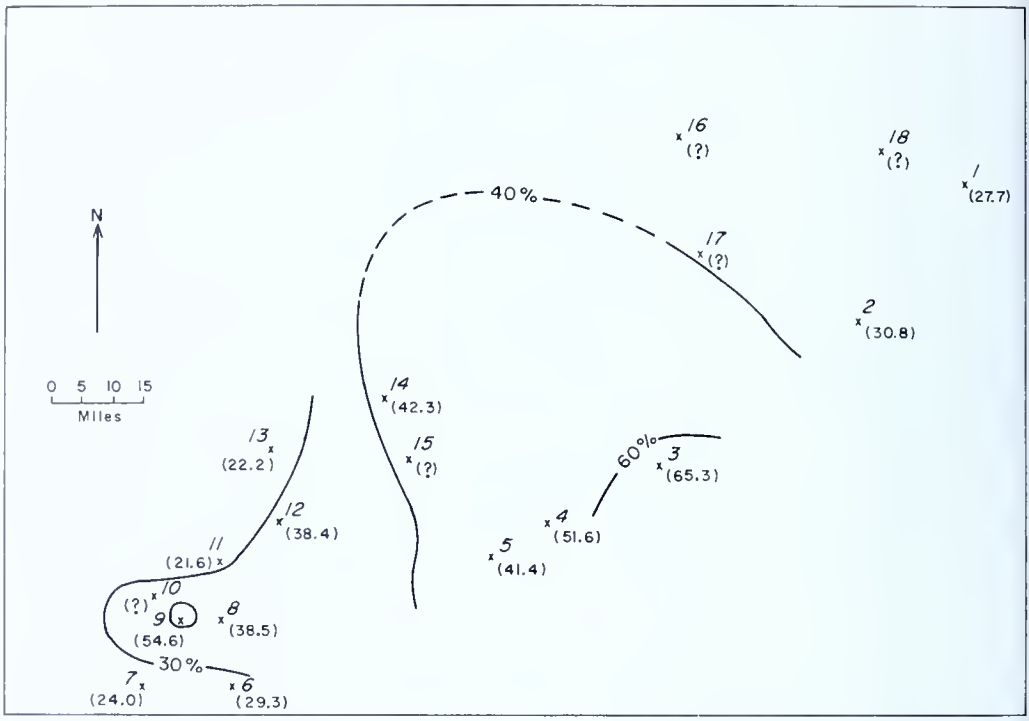

FIGURE 51. Isolith map af percentage concentrations of Type I beds in Siltstone Unit 3.

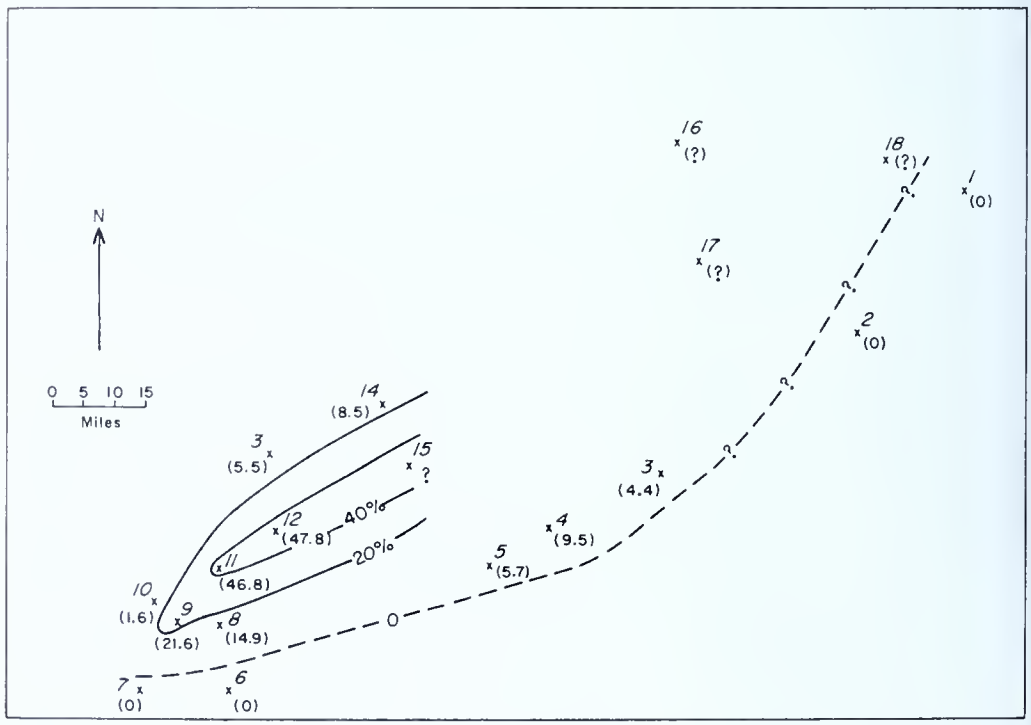

FIGURE 52. Isolith map of percentage cancentration of Type II beds in Siltstone Unit 3.

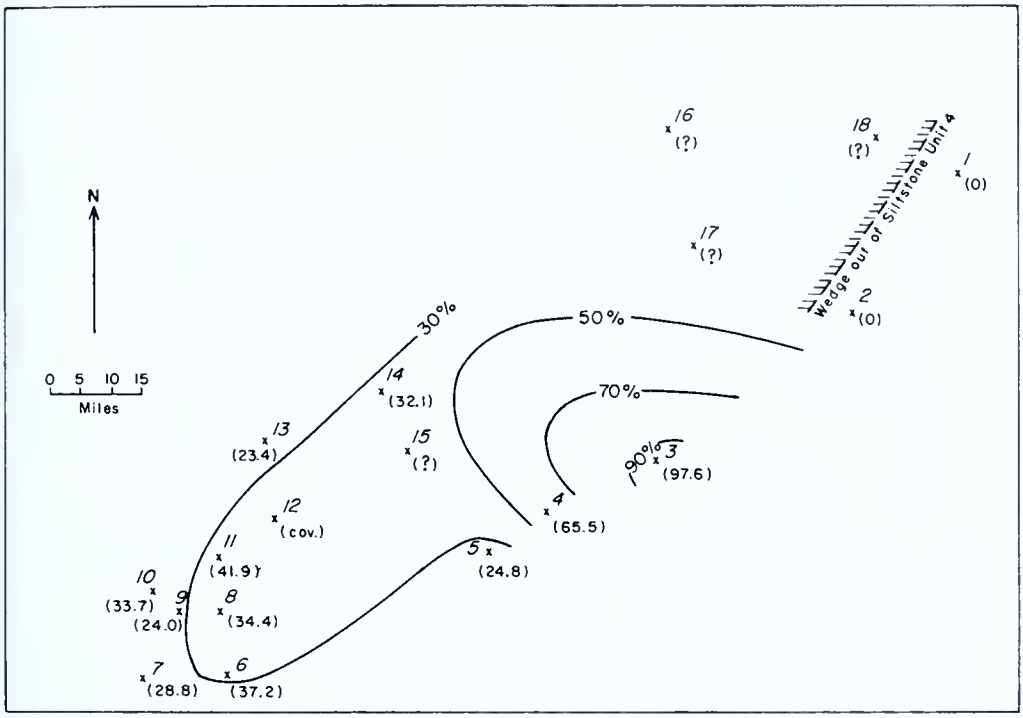

FIGURE 53. Isolith map of percentage cancentrotian of Type I beds in Siltstone Unit 4.

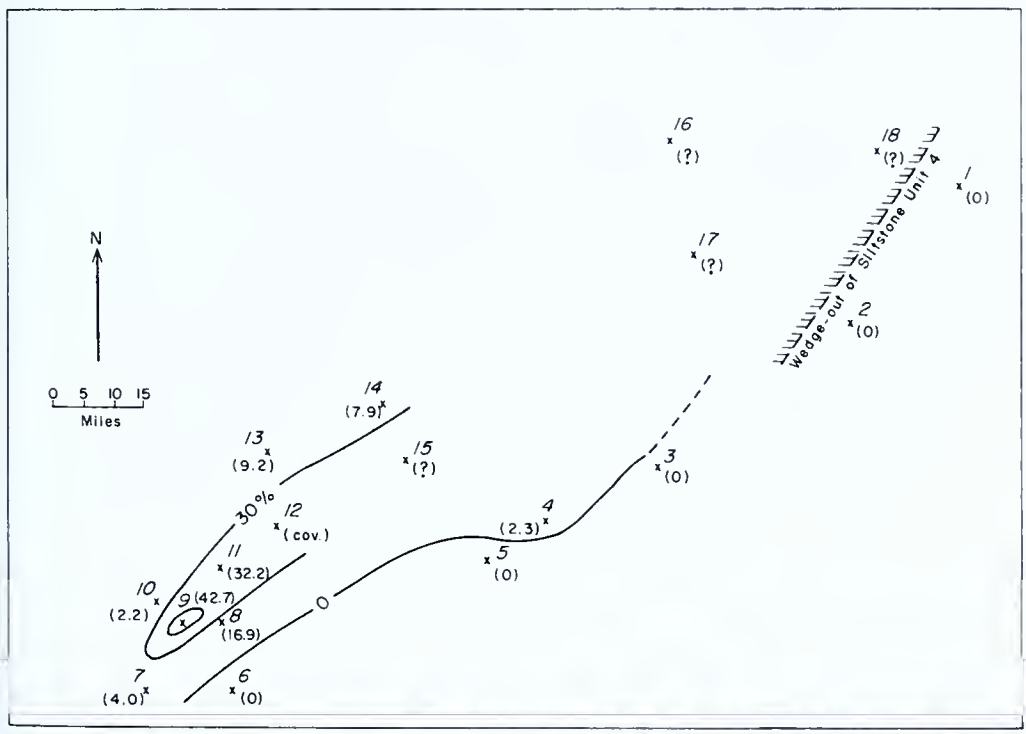

FIGURE 54. Isolith mop of percentage concentration of Type II beds in Siltstone Unit 4.

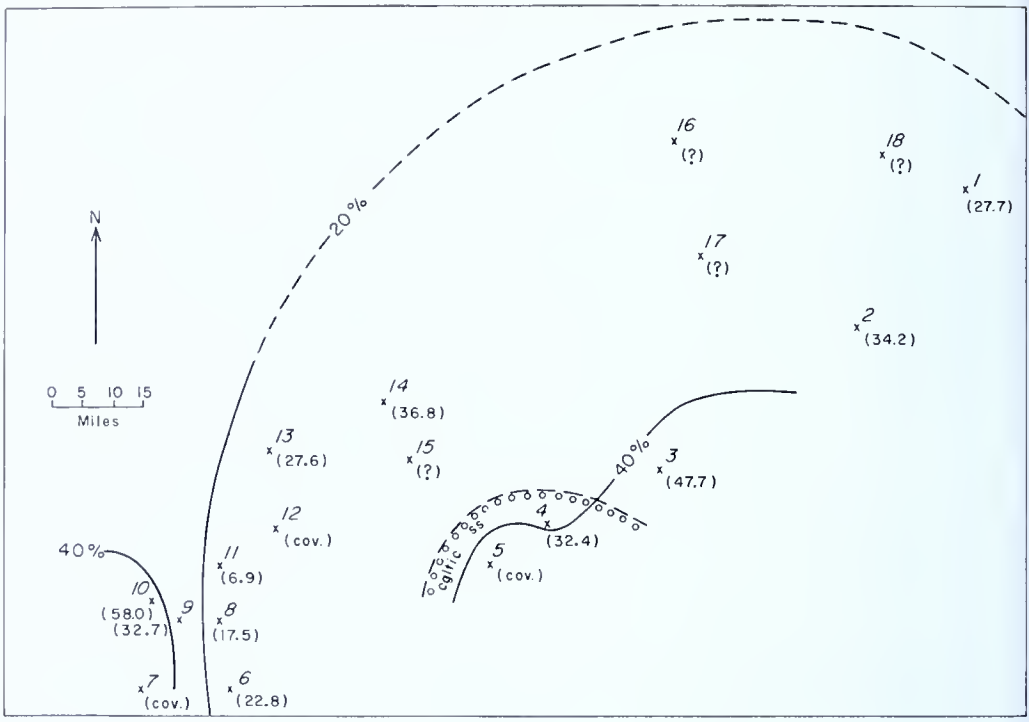

FIGURE 55. Isolith map of percentoge concentrations of Type I beds in Siltstone Unit 5.

is northeast, and they enclose lobate areas of relatively high concentration which are concave to the southeast. Smaller lobes concave to the east lie westward of the major features.

Second, the highest percentage concentrations of Type I beds and conglomeratic sandstones are centered in the vicinity of Bowmanstown; these coincide roughly with the area of greatest thickness for Units 3 and 5. Unit 4, thinning regionally to the southeast, is almost a wedge-edge at Bowmantown, but is composed nearly entirely of Type I beds at that locality.

Third, the dominant trend of isoliths for Type II beds is strongly east-northeast, and contours enclose narrow areas of highest concentration which open to the east.

Fourth, there is a northwestward migration of comparable isoliths for Type II beds from Unit 3 to Unit 5. This is in agreement with the regional variation of the base of the Catskill Formation (Plate 1).

Fifth, Type II beds are absent or rare in the southeasternmost region of the study.

Interpretations of these characteristics of rock type distributions are given in the section treating paleogeography.

DISTRIBUTION OF COLOR

General

As previously noted, rock color is of primary importance in the Upper Devonian section of Pennsylvania because the Catskill Formation is distinguished from the Trimmers Rock Member of the Fort Littleton Formation by the presence of mappable hues of red (Hoskins and others, 1963, p. 161-162). The regional stratigraphic position of these lowest Catskill red beds reveal the temporal and spatial characteristics of the deltaic deposition. Similarly, color variation within the Trimmers Rock is of significance in environmental reconstruction.

Base of the Catskill

The regional isopach map of the Trimmers Rock Member (Figure 4) shows that the lowest Catskill red bed occupies successively lower stratigraphic positions from northwest to southeast in Pennsylvania. That this is accomplished through lateral interfingering with the Trimmers Rock is suggested in Figure 3.

The regional relationships between the Trimmers Rock and the Catskill are indicated by the configuration of the upper line in Figure 56A. This line joins all points denoting the lowest occurrence of Catskill red beds. The horizontal line below represents the top of Shale Unit 2, the datum for the stratigraphic study.

In Figure 56A, the base of the Catskill is lowest in the south, except at Bush Kill and Port Jervis where the Delaware River Flags intervene between the Trimmers Rock and lowest red bed. From south to north (Stations 6 through 13) the lowest red bed occurs at successively higher stratigraphic positions. The base of the Catskill is about 1500 feet higher in the section at Shamokin Dam than at Marysville, which lies 37 miles, S10W of Shamokin Dam. From Shamokin Dam east to Catawissa, the lowest red bed occurs at perceptibly lower positions in the section but is still at a much higher stratigraphic level than in the southern tier of exposures (Frakes, 1963).

This three-dimensional picture of the base of the Catskill over a region of several thousand square miles shows that the Catskill was deposited first in the southeast and progressively later toward the northwest.

Reddish Colors

The reddish rocks (Suite J) within the Trimmers Rock are shown by the lower irregular line in Figure 56A; this line represents the lowest occurrence of reddish colors. For the most part reddish colored rocks are concentrated in the lower Susquehanna Valley although small amounts are present immediately below the Catskill from Marysville east to Bowmanstown.

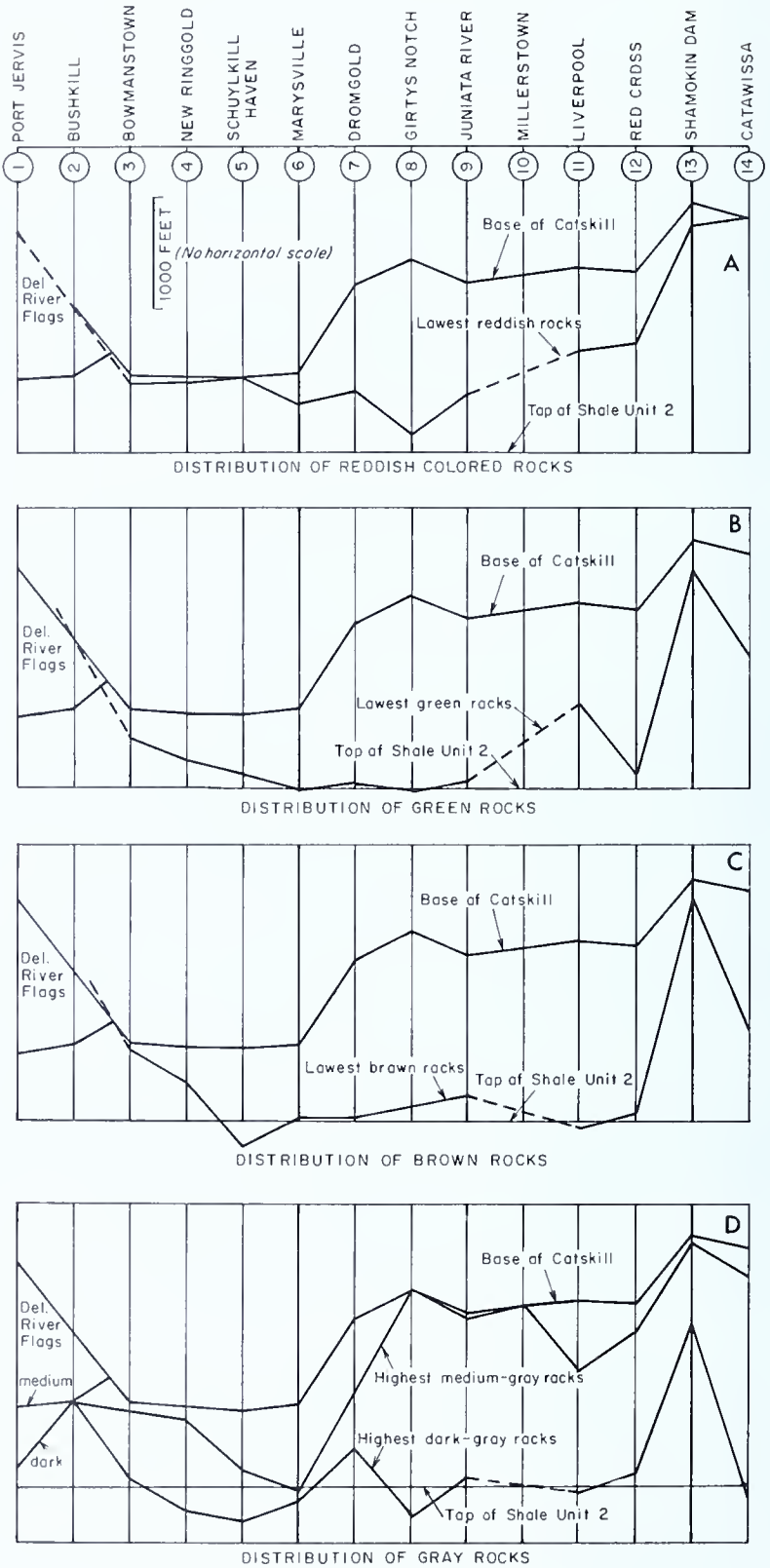

FIGURE 56. Distribution of color in the Trimmers Rock.

The fact that the line depicting the lowest occurrence of reddish-colored strata in the Trimmers Rock is quite irregular with respect to both the top of Siltstone Unit 2 and the base of the Catskill suggests that these colors have little stratigraphic value. This suggestion is strengthened by the fact that these colors are not mappable in the field while the basal red bed of the Catskill is mappable.

Green Colors

The lower irregular line in Figure 56B represents the lowest occurrence of green strata in the Trimmers Rock. Greens are absent from the section east of Bowmanstown, but rocks of these colors constitute a large portion of the Trimmers Rock throughout the remainder of the region. From Bowmanstown to the Juniata River section the line is closely parallel to rock-stratigraphic units in the Trimmers Rock and to the base of the Catskill; stratigraphic control of green colors is strongly indicated. The fact that reddish colors of the Trimmers Rock do not occur below green strata suggests the dependence of red coloration on green.

Brown Colors

The regional stratigraphic position of the lowest brown colors is shown in Figure 56C. Brown colors show the best agreement of any color suite with rock-stratigraphic units in the Trimmers Rock. From Schuylkill Haven to Red Cross the line representing the lowest occurrence of brown rocks shows comparatively little deviation from the top of Shale Unit 2.

With few exceptions, the lowest brown rocks lie below the lowest exposures of reddish and green strata. As noted, the cause of brown coloration appears to be limonitization of iron-bearing minerals. The regional abundance of brown colors possibly reflects the extent of this process, which is either an earlier stage than the development of hematite staining or is operative on a more widespread suite of minerals. The latter suggestion is more in accord with the apparent stratigraphic control on distribution of brown colors.

Gray Colors

The distribution of gray colors is shown in Figure 56D, where the lowest line represents the highest occurrence of dark-gray colors, the intermediate one the highest medium gray, and the highest, the base of the Catskill. Extreme irregularity of the plots is explained by localized variations in grayness and the difficulty in differentiating the various shades.

The most significant aspect of the diagram is the concentration of dark-gray colors at the base of the section. Additionally, there is a general rough parallelism between the highest dark-gray rocks and the base of the Catskill.

Summary

From consideration of the color diagrams, certain generalizations can be made about distribution of color in Upper Devonian rocks of this region. First, there is an ordered, although not necessarily complete, sequence of colors encountered in traversing a section from bottom to top. The lowest strata of the Trimmers Rock are dark gray and are often associated with dark Type II siltstones and shales of the Harrell Member. The dark grays grade upward into medium- and light-gray rocks which are continuous to the top of the Trimmers Rock. Brown strata usually occur above the highest dark-gray rocks and are in turn followed by first green-colored rocks and then those of reddish hue. Near the top of the Trimmers Rock, therefore, there is a great variety of color, in that light- and medium-gray, brown, green and reddish-colored rocks are all common.

Both brown rocks and green rocks are distributed so as to indicate strong stratigraphic control of color while gray colors and red colors yield inconclusive evidence of control because of wide variability. The base of the Catskill Formation occupies successively higher positions toward the northwest and this is paralleled by other colors in the Trimmers Rock.

DISTRIBUTION OF LANDSLIDE DEPOSITS

Figure 57 depicts variation in regional and stratigraphic location of the 48 layers containing evidence of subaqueous landsliding prior to final deposition. In considering trends in lowest occurrences of lithologic features, it must be remembered that long covered intervals in the section may conceal still lower occurrences. This factor is at a minimum in the present study.

At Port Jervis, evidence of landsliding is common throughout the section, but all other sections display concentrations of such structures above a certain level which is variable in position. Considerable variation in the position of the lowest structures occurs in the southern tier of exposures from Port Jervis to Marysville, but a trend upward and to the right is roughly established by the Port Jervis, New Ringgold, and Marysville localities. The remaining stations show an exceptionally well-developed trend. The lowest occurrence of landslide deposits clearly traverses the section upward toward the northwest.

Another significant aspect of the distribution of these structures is their restriction to the thickest portion of the individual siltstone units. This is very well shown in Units 2, 3, 4, 5, and 8, and less well in Units 6 and 7.

It is also significant that these structures are restricted laterally within any given siltstone unit. Thus, Unit 3 occurrences are limited to three stations, Unit 4 structures to three stations, Unit 5 to four, Unit 6 to two, Unit 7 to one, Unit 8 to three, and Unit 10 to one station.

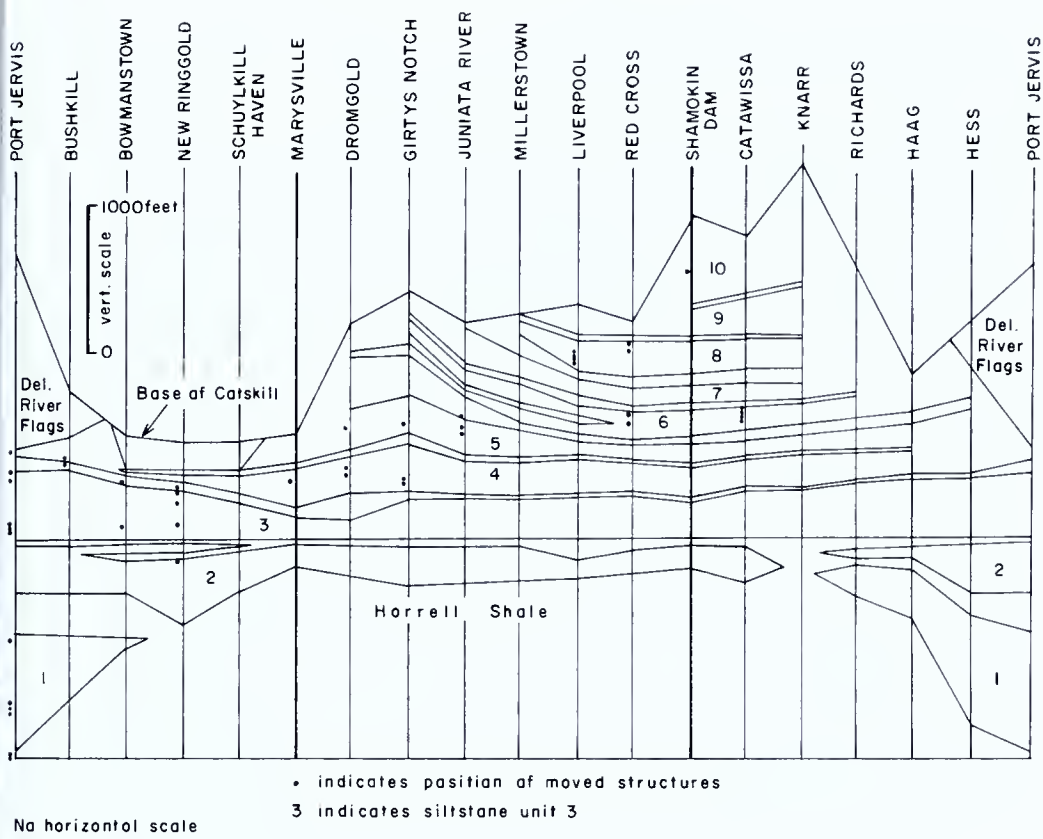

FIGURE 57. Distribution of landslide deposits.

These characteristics of the regional stratigraphic distribution of laterally-moved debris are of utmost importance in determining basin geometry. The region where such structures came to rest and are now preserved was near that of thickest accumulation of sediment.

DISTRIBUTION OF FISSILITY

In the measured sections (Appendix A) fissility type is designated by the numbers 1, 2, and 3. Fissility type 1 is well-developed or good fissility, type 3 is poorly developed fissility, and the rather subjective type 2 is fair or intermediate in degree of development. Variation of these characteristics in shale units of surface sections is summarized in Figure 58.

Fissility is best developed toward the south and east; in shales of the northwestern stations, fissility is usually poorly developed. Fairly well developed fissility has the widest distribution but is concentrated in the central portion of the area studied.

More detailed information can be gained by study of the individual shale units in the diagram. There is a general decrease in the development of fissility from left to right (southeast to northwest) in several shale units. This

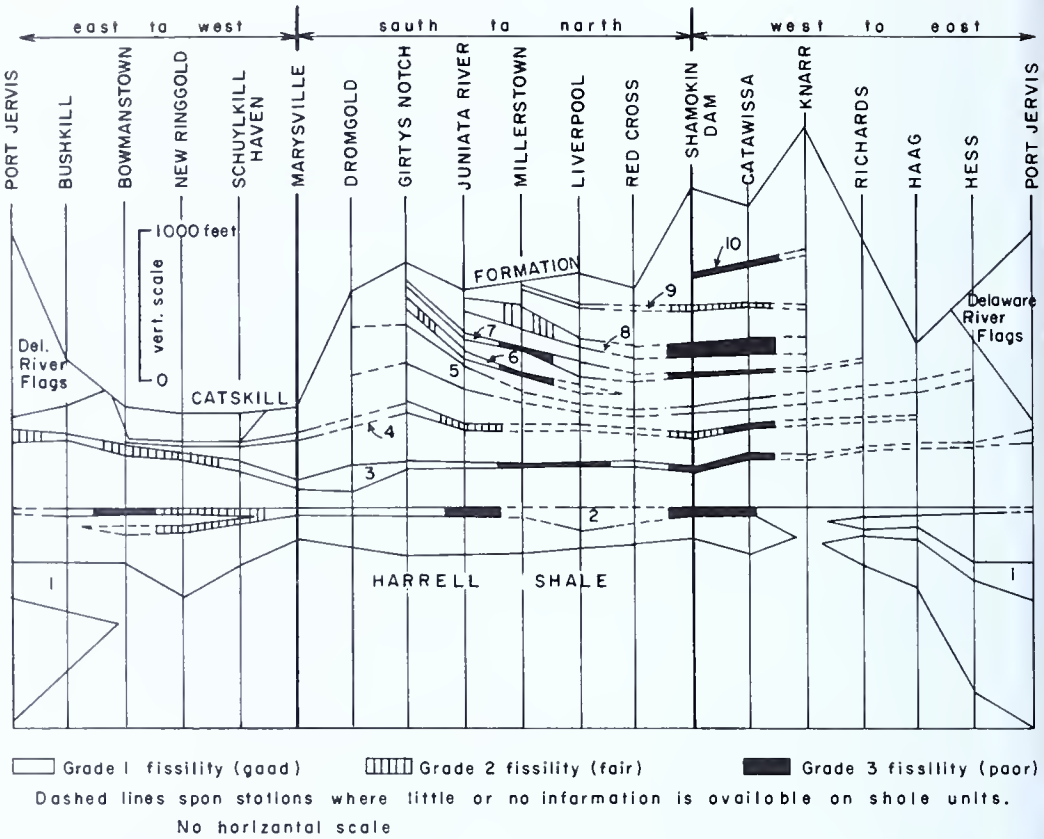

FIGURE 58. Variation of fissility in shale units of the Trimmers Rock.

gradation is regular in Shale Units 4, 6, and 9; less perfect, but only in that the intermediate grade is out-of-place, in Shale Units 3 and 8; and complicated by reversals in Units 2 and 7. Units 5 and 10 show no variation in fissility, and no data are available for Unit 1.

Concentration of poor fissility in the northwest and good fissility in the southeast is perhaps best explained by northwestward migration of environment as with other lithic features. Several factors may conceivably have played a part in causing such systematic lateral variations in fissility in shale units of the Trimmers Rock. These include: 1) variation in intensity of tectonic deformation; 2) variation in thickness of overburden; 3) variation in abundance of burrowing organisms; and 4) variation in texture of the shale.

In a general way, intensity of tectonic deformation in Pennsylvania increases southeastwardly from the Appalachian Plateau (see Gray and others, 1960). Sections measured in this study have therefore been subjected to varying amounts of deformation, and if the formation of fissility is indeed related to major structure, the observed pattern of good fissility in the southeast and poor fissility in the northwest can perhaps be attributed to this factor. It is not possible, however, to explain the northwestward migration

through time of poorly-developed fissility by tectonism alone. If regional structure is a factor, it is not the only one.

Variation in amount of overburden might be considered as a cause of variation in fissility such that fissility develops with increased loading. This factor is probably not of prime importance because many thick shales showing poor fissility occur below shales showing well-developed fissility.

The extent to which burrowing organisms disrupted the internal structure of the original mud undoubtedly contributes to the degree of development of fissility now seen in the rock. It is likely that the presence of stratification, representing boundaries between thin layers of differing composition or grain size, also contributes to the development of planes of fissility. Breaking of these planar features and mixing of the constituent materials by worms or mollusks removes the bed-parallel fabric resulting from deposition and hence inhibits the formation of planes of fissility. This process cannot be responsible for all poorly-fissile shale, however, because many rocks of this type contain little or no evidence of animal activity on bedding planes.

The increase in abundance of poorly-fissile shales toward the northwest coincides with changes in other lithologic features, for example, decrease in concentration of Type I beds. This strongly suggests that variability in the depositional processes was greatest from southeast to northwest. It is therefore considered likely that regional variation in fissility is in part the result of corresponding variation in lithologic character of the shales.

DISTRIBUTION OF TRACE FOSSILS

The locations of measurement units containing trace fossils are plotted on Figure 59. In interpreting the diagram it must be noted that trace fossils in the Trimmers Rock are best seen on the soles of graywacke beds although the features are sometimes observed within beds. Such factors as dip of the beds and extent of differential weathering may, therefore, establish a bias for any particular station.

The distribution of trace fossils in the Trimmers Rock appears to be environmentally controlled, but not to the extent that burrowing and benthonic organisms were restricted entirely to one small portion of the region at any given time. Rather, the evidence suggests that these animals had a wide range of adaptability and simply concentrated in certain favored areas. The locus of these preferred areas is irregularly upward toward the northwest, in a manner similar to the stratigraphic shifting of most physical features of the Trimmers Rock.

Another significant characteristic of the distribution is the relative scarcity of trace fossils near the top of the sections. Generally, trace fossils are also less abundant near the base of most sections, but Bowmanstown, Liverpool, and Catawissa are notable exceptions.

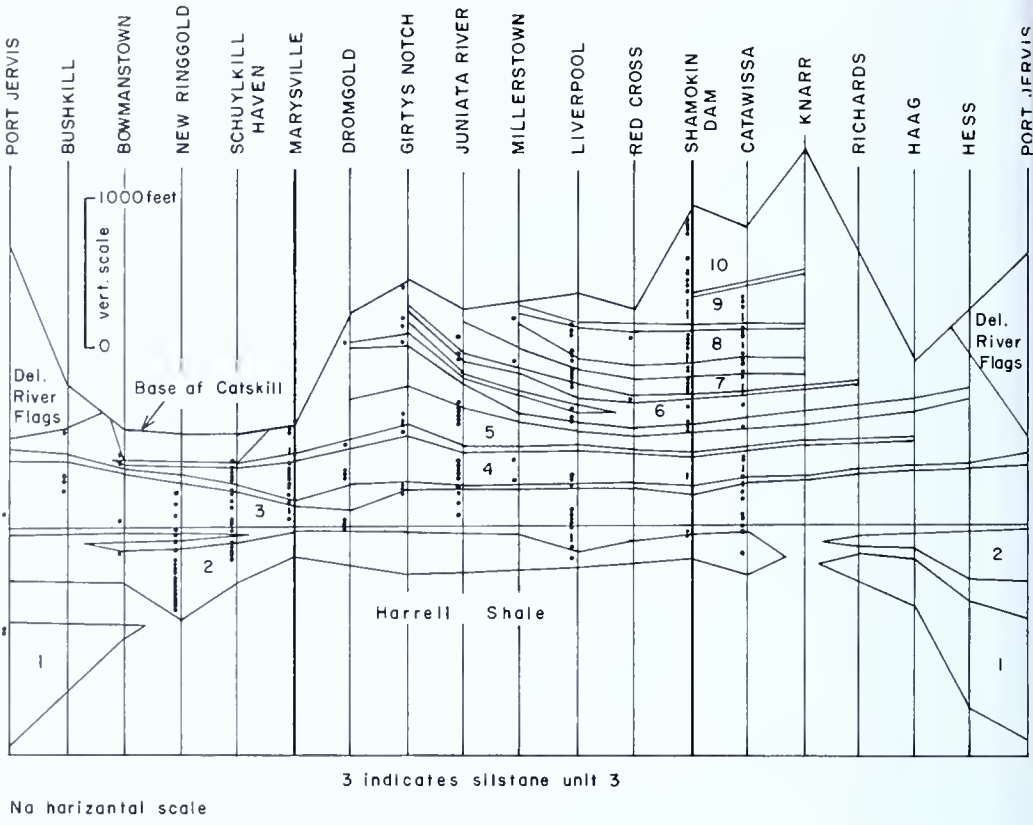

FIGURE 59. Distribution of trace fossils.

DISTRIBUTION OF FOSSIL-FRAGMENT LAYERS

The regional stratigraphic distribution of fossil-fragment layers is shown in Figure 60. With the exception of the Port Jervis section, these features are abundantly developed in all sections studied.

The development of fossil-fragment layers appears to be closely related to the lithostratigraphic units delineated in this study. That is, in the broad region north and west of Schuylkill Haven the lowest occurrence of fossil-fragment layers tends to lie near the base of Siltstone Unit 3.

Fossil-fragment layers occur in Siltstone Unit 1 at Port Jervis and progessively higher in the region westward to Schuylkill Haven, excluding covered sections. In this region there is thus some suggestion of systematic variation within individual siltstone units.

DISTRIBUTION OF CROSS STRATIFICATION

The regional stratigraphic distribution of cross stratification is plotted in Figure 61. There is a marked resemblance to the distribution of fossil-fragment layers (Figure 60.) In fact, the only significant difference between the

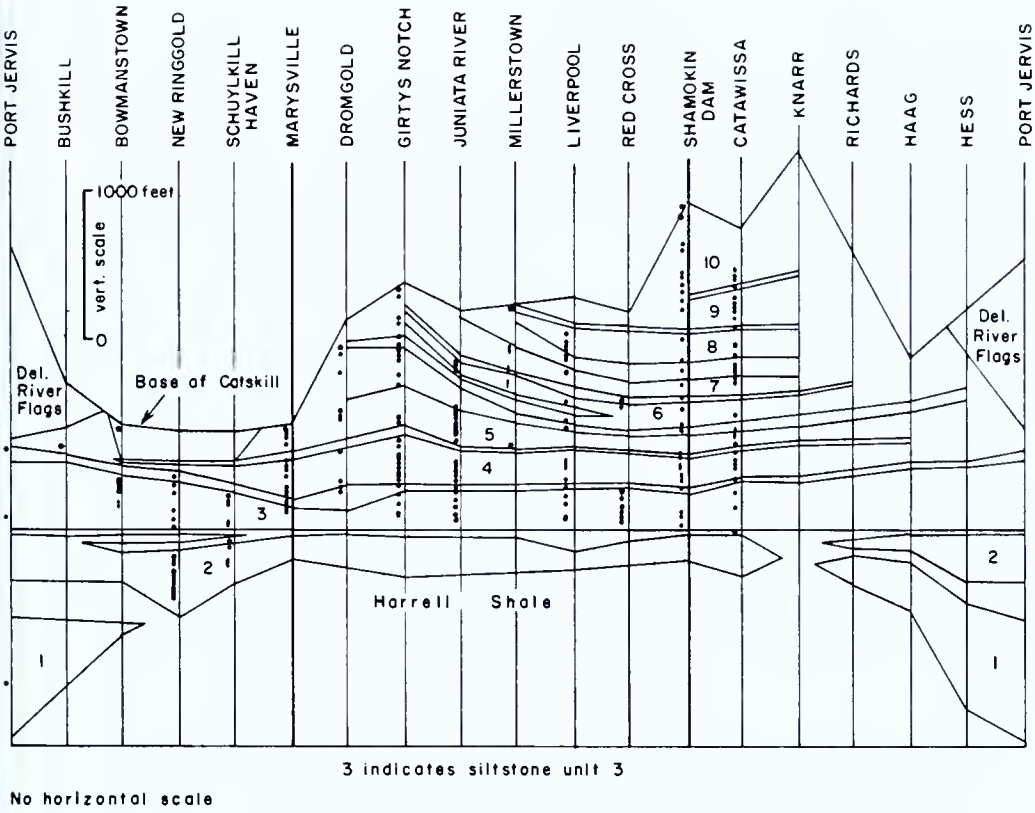

FIGURE 60. Distribution of fossil-fragment layers.

two plots is the near absence of cross stratification in the Schuylkill Haven, Marysville, and Dromgold sections where fossil-fragment layers are common.

The parallelism between occurrences of cross stratification and fossil-fragment zones suggests that both features originated under similar conditions. This widespread parallelism is perhaps best explained by reference to the individual bed which contains a fossil-fragment layer. Above the fragmental portion of the stratum, a series of cross stratified sets is commonly present. Although only one or the other may be present, the common association of the two suggests common conditions of origin.

DISTRIBUTION OF LOAD-STRUCTURES

The regional stratigraphic distribution of load-structures is shown in Figure 62. There appears to be good stratigraphic control of these structures in the region bounded by the Liverpool, Red Cross, Shamokin Dam, and Catawissa sections, in that the lowest occurrence is approximately at the same level. Between New Ringgold and Millerstown, on the other hand, intraunit variation is marked. The position of the lowest load-structure in this region varies systematically in the section upward toward the northwest.

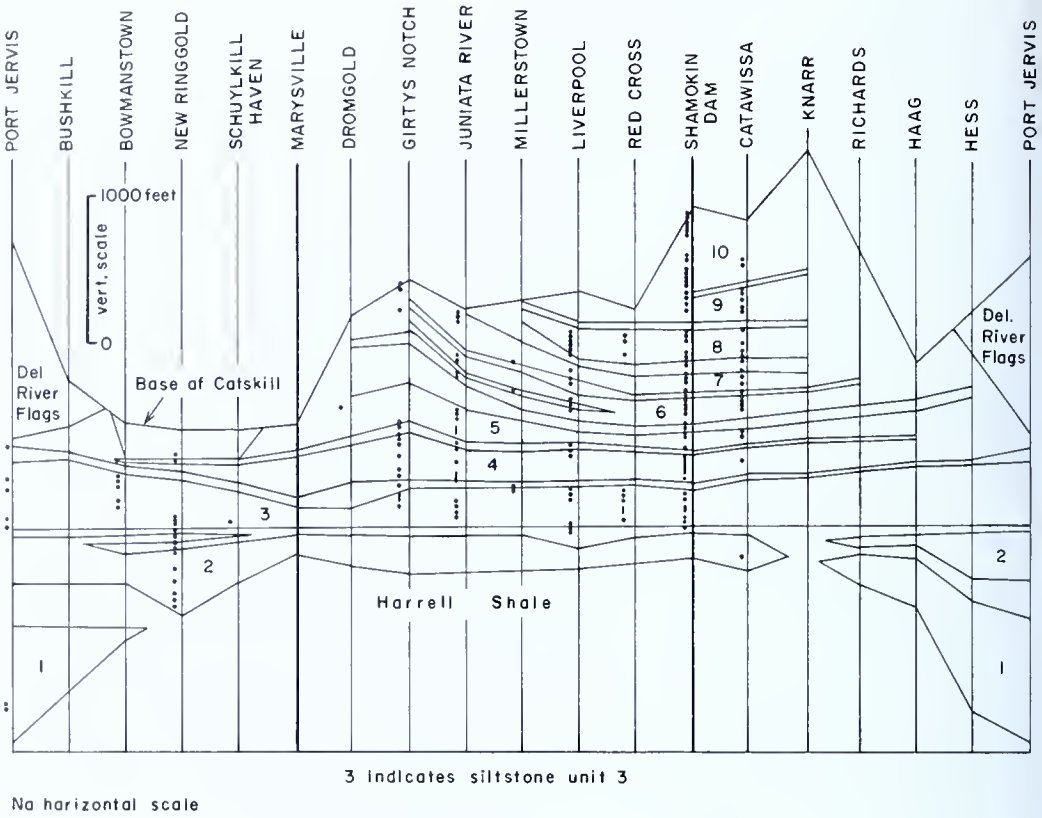

FIGURE 61. Distribution of cross stratification.

Apparently the stratigraphic position of strata containing load-structures continues to be lower toward the east except for a "high" at Bowmanstown. This lack of load-structures in Siltstone Unit 2 at Bowmanstown is explained by the scarcity of Type I beds in Unit 2 at that locality. Instead, Type II beds constitute the predominant lithologic type, and they are regionally lacking in load-structures.

DIRECTIONAL CURRENT-STRUCTURES

GENERAL

One of the principal reasons for undertaking a detailed lithostratigraphic study in conjunction with sedimentologic investigations is that in this way variation in type, size, and orientation of sedimentary structures may be detected within relatively thin stratigraphic bodies. The most significant results of such parallel studies are twofold: 1)determination of relationships between rock unit character such as thickness or sand-shale ratio, and the type, size, and orientation of sedimentary structures; and 2) determination of the flow-history of a current by consideration of the areal variability of sedimentary

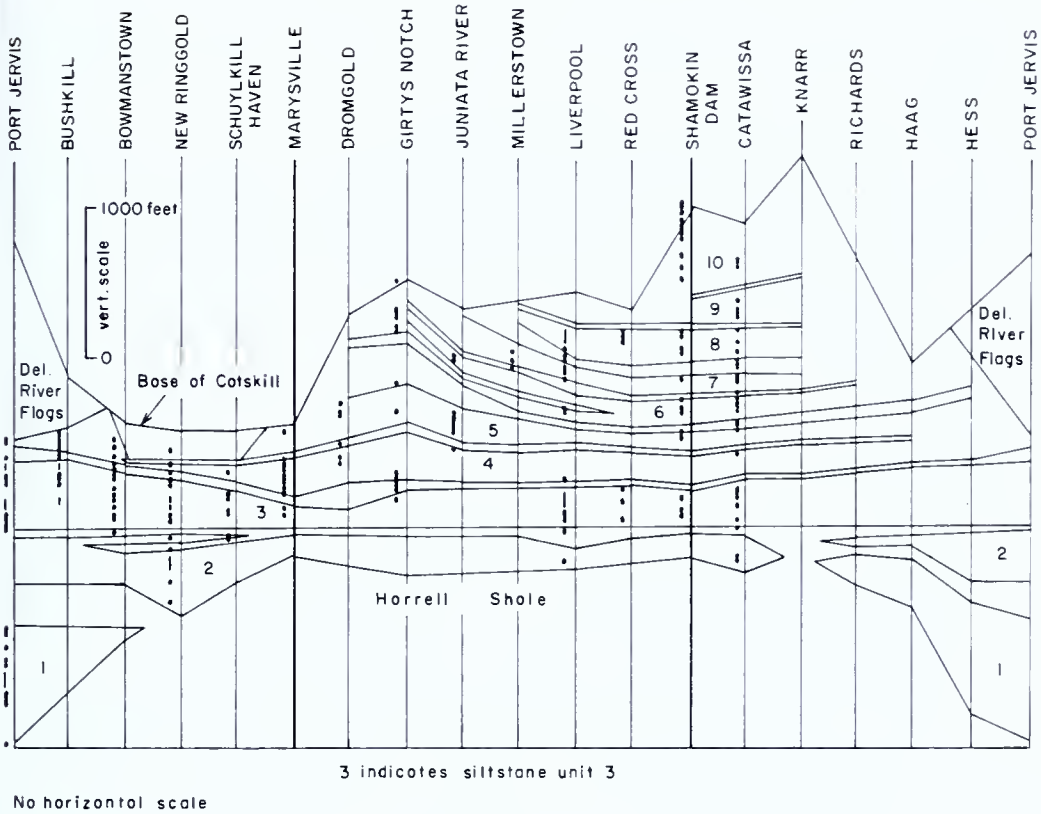

FIGURE 62. Distribution of load-structures.

structures in a few closely-spaced strata. The first result leads to such important paleogeographic generalizations as location, orientation, and migration through time of submarine paleoslopes. The second result has both paleogeographic and paleo-environmental significance in that the course of the current can be charted, variations in its physical characteristics can be ascertained, and relationships to bathymetry may be deduced.

PREVIOUS WORK

The directional current-structures of the nonred Upper Devonian rocks of Pennsylvania and New York have been examined by several authors (Sheldon, 1929; Rich, 1951; Kuenen, 1956; Sutton, 1959; McIver, 1960, 1961; Frakes, 1961; Leeper, 1963).

Sheldon (1929) observed the orientation of lee-side cross-lamination associated with ripple marks in the section from the Sherburne Sandstone to the Enfield Shale at Cayuga Lake, New York. In this "Portage" section, she noted that orientation of the laminae shifted from roughly northwest-southeast to north-south upward from the base of the Sherburne to the middle of the Enfield. From this, Sheldon concluded that the currents which deposited

the Sherburne flowed from the northeast but that through time the direction of current flow shifted clockwise so that currents flowed from the east during deposition of the Enfield.

In studying the same region Sutton (1959) noted variation in the orientation of flute casts from the base of the Sherburne Sandstone to the Cayuta Formation. Thus, the Cashaqua Formation contains flute casts indicating currents from the southeast while flute-casts in both older and younger units suggest westwardly flow.

McIver (1960, 1961) studied the arenaceous rocks of the nonred Upper Devonian throughout the Appalachian region. On this regional scale McIver found that currents which deposited the "Portage facies" flowed generally westward and that currents which deposited the "Chemung facies" flowed toward the northwest. By observing variation in the orientation of directional current-structures through four stratigraphic sections, McIver demonstrated this clockwise shift from the base of the "Portage" to the top of the "Chemung" (1961, pp. 270-284). The mean direction at the base was shown to be significantly different from the mean direction at the top of the section in three of four cases.

In a local study of the nonred Upper Devonian in central Pennsylvania, Frakes (1961) noted east to west transport and found that some currents moved from south to north.

Leeper (1963) found that ripple marks and associated structures of the "Chemung" of Somerset County, Pennsylvania indicated currents which flowed from east to west.

RIPPLE MARKS

In the region of this study, ripple mark is the most abundant directional current-structure observed. Most ripple marks in the Trimmers Rock Member of the Fort Littleton Formation show only slight asymmetry, and it is therefore frequently difficult to ascertain the direction of current flow. Asymmetric ripple marks in the central portion of this region, however, yield a consistent direction of transport toward the north and northwest. It is assumed that the more symmetric ripples conform to this movement pattern.

The orientation of 145 continuous ripple marks from stations 1 through 14 are summarized in the outer circle of Figure 63. The arrows plotted on the diagram represent current directions determined from 16 asymmetric ripples. Orientation data from 9 discontinuous ripple marks are shown in the inner circle. All ripple marks summarized in this rose diagram occur in Type I beds.

A fair estimate of the mean direction of ripple-forming currents may be obtained by inspection of the diagram. The modal class of the distribution of symmetric ripples (61°-75°, in the first quadrant) indicates currents flowing

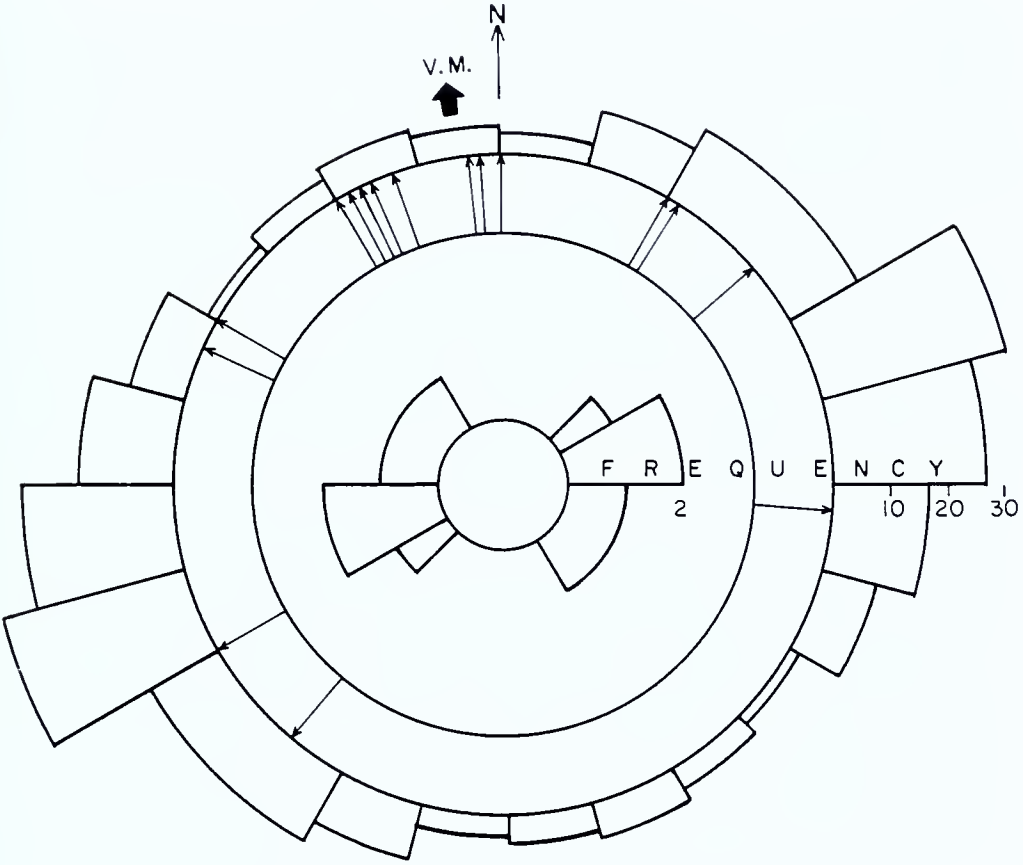

FIGURE 63. Rose diagram of ripple-mark orientation at stations 1–14. *Outer circle:* plat af orientation of 145 continuous ripple marks in Type I beds. Arrows represent current directians determined fram 16 asymmetric ripples. *Inner circle:* plot af orientation af 9 discontinuous ripple marks in Type I beds. *V.M.*: vector mean of 16 current directions determined from asymmetric ripple marks = 352°.

along a trend of about 160°-340°. The sense of this flow, as given by the mode of flow directions deduced from asymmetric ripple marks, is approximately 340°. This compares favorably with the vector mean (Curray, 1956) of the 16 asymmetric ripples, calculated to have a value of 352°.

The orientation of discontinuous ripple marks is nearly coincident with the orientation of continuous ripple marks as judged by comparison of the data in Figure 63. This further supports the contention that discontinuous ripple marks are oriented in the same manner as continuous structures with respect to the depositing current.

Ripple marks are notably scarce in Type II beds. Only one occurrence was observed, in Siltstone Unit 6 at Girtys Notch. This structure is oriented N45W and is apparently symmetrical.

The vector mean of ripple mark data in this region (352°) is quite different from that obtained from 66 ripples summarized from south-central Pennsyl-

vania (309°). It is likely that the geographic separation of the two regions accounts for this sizable divergence. For Type I beds, ripple-forming currents in eastern Pennsylvania flowed dominantly to the north, and those in the south-central part of the state flowed toward the northwest.

SOLE MARKS

Flute casts, groove casts, and prod casts in Type I beds at stations 1-14 are plotted in Figure 64. The vector mean for flute casts is 279° and for prod casts is 268°. A vector mean for groove casts was not calculated because these structures yield a current trend rather than a current sense. The modal class of groove casts, however, includes the vector mean for flute casts and is adjacent to that of prod casts, indicating that currents which produced sole marks in this region flowed chiefly toward the west.

The problem immediately apparent is the coincidence of these currents with northerly-flowing currents indicated by ripple marks in Type I beds of

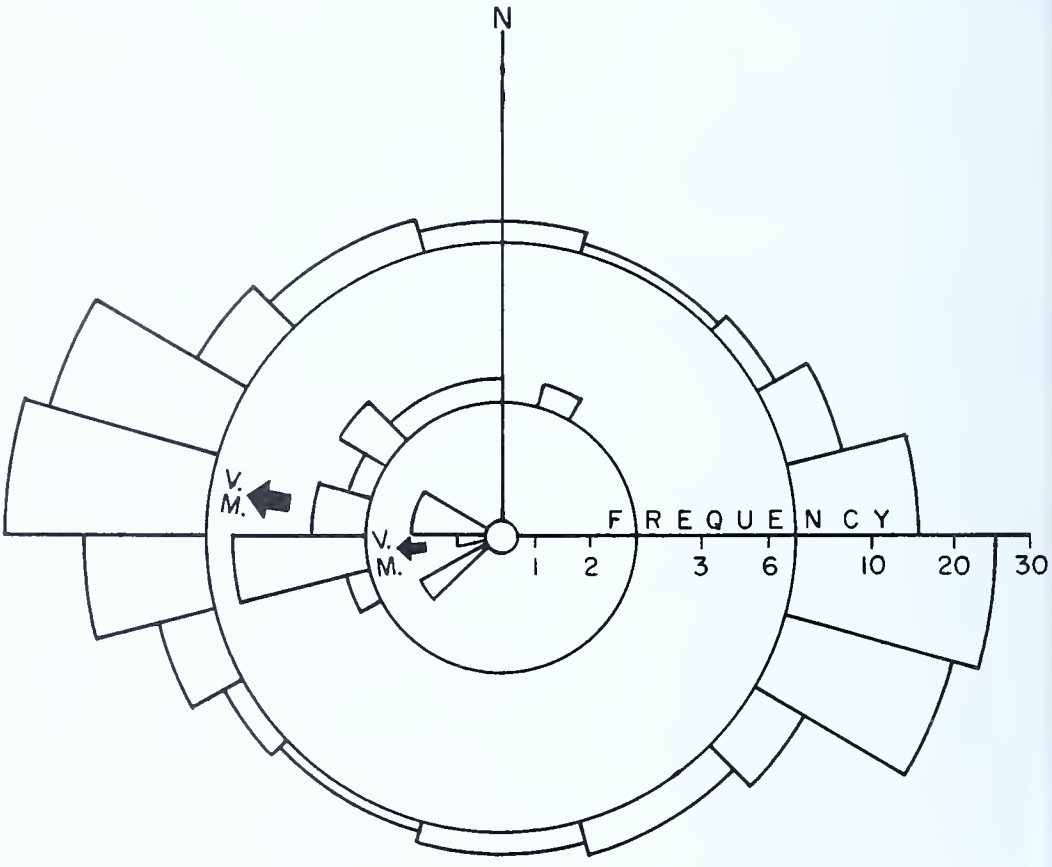

FIGURE 64. Orientation of sole marks in Type I beds at statians 1–14. *Outer circle:* orientatian of 95 graove casts. *Second circle:* orientation of 16 flute casts; *V.M.:* vector mean af flute casts = 279°. *Inner circle:* arientatian of 7 prod casts; *V.M.:* vector mean of prad casts = 268°.

the same region. Collectively, Type I beds thus contain sole marks indicating flow to the west and also ripple marks indicating flow toward the north. In a few examples, associated beds show divergent directions, one containing ripple marks showing northward flow and another sole marks showing westward flow. Within single beds, however, sole marks and ripple marks give nearly parallel flow directions. *In no single bed were widely divergent flow directions observed.*

Because of relative position in the bed, it might be supposed that sole marks delineate the early flow direction of a current, and ripple marks trace the direction of later movement. From this, it might be suggested that currents which marked the substratum flowed westwardly and were deflected clockwise to a northwardly flow in their later ripple-forming stages. The regional relationships in the Catskill delta and physical variation with the Trimmers Rock (Figures 51-62) suggest instead that gravity-driven currents flowed northward in their early stages and were deflected counterclockwise, probably by velocity loss, to westwardly flow. Thus, on a regional basis, ripple marks form at earlier, higher-energy levels of flow than sole marks.

The lack of divergent flow-directions in single beds further suggests that deflection was the result of a regional rather than a local cause. If deflection of these gravity-driven currents resulted from velocity loss, the most likely cause would be a regional decrease in the slope of the floor. Closely associated beds showing divergent directions might merely represent deposits from currents originating at widely separated places or at different stages of deflection.

The discussion of directional current-structures has thus far dealt with structures in Type I beds. The intimately associated Type II beds display sole marks as the dominant structure, but even these are infrequently observed because the soles of Types II beds are seldom exposed by weathering.

Figure 65 shows the orientation of sole marks from Type II beds at stations 1-14. The most obvious characteristic of the plot is the narrow dispersion about the vector mean of 269°. In contrast to data from Type I beds, there is no evidence of current deflection in Type II beds. Sole marks in Type II beds indicate that this rock-type was deposited by currents which flowed, with little variation, from east to west.

Perhaps the source area for Type II beds lay considerably farther to the east; the high percentage of matrix in Type II beds favors a greater distance of transport. Or perhaps Type II beds were laid down during the very late stages of currents depositing Type I beds. In their late stages, currents depositing Type I beds essentially paralleled the westward flow of currents depositing Type II beds. This relationship strongly suggests that Type II currents flowed parallel to and below the break in slope which deflected Type I currents.

Close interbedding of Types I and II showing divergent paleocurrent di-

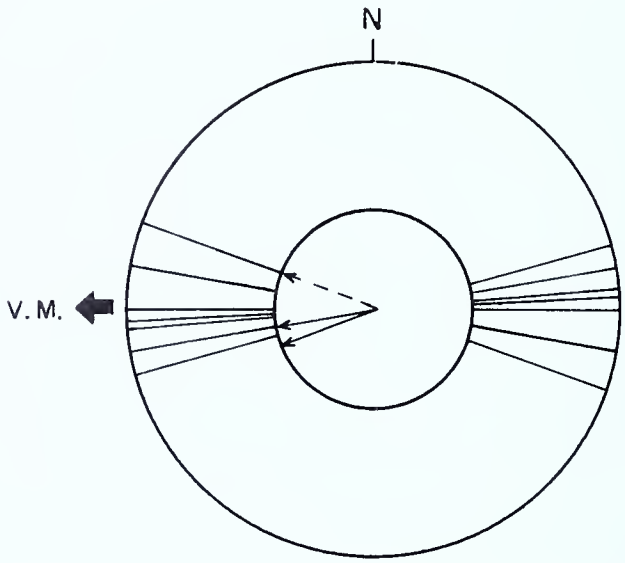

FIGURE 65. Orientation of sole marks in Type II beds at stations 1–14. *Outer circle:* orientation of 7 groove casts. *Inner circle:* solid arrows—orientation of 2 flute casts; dashed arrow—orientation of prod cast. *V.M.:* vector mean of all sole marks = 269°.

rections can be easily explained by a number of methods: variations in velocity, density, and distance from the source, lateral spreading of the currents as they wane, and irregularities in the floor.

PALEOGEOGRAPHY

GENERAL

During the Middle and Late Devonian, eastern Pennsylvania was an area of active sediment accumulation, mostly in a marine environment as indicated by organisms preserved in the rocks (Willard, 1939). This marine aspect applies to portions of the Catskill Formation as well as to the nonred section (Claypole, 1885; Frakes, 1961; Dyson, 1963).

To explain the geographically variable position of the base of the Catskill, Barrell (1913, p. 465) postulated that the Upper Devonian rocks of the Appalachian region were deposited in the form of a large delta which built northwestward through time. Rich (1951), McIver (1960), and Sutton (1960, 1963) attempted to distinguish the topset, foreset, and bottomset units of this delta in the rocks of the succession. For the Upper Devonian of the central Appalachians, McIver (1960) proposed a north-south source region which changed trend to northeast-southwest through the epoch, and which shed detritus toward the west and northwest.

Although Barrell (1913) made a concerted effort to show that the Catskill Formation is of sub-aerial origin, his conclusion is doubtful in light of modern understanding of the origin of such features as red coloration and ripple marks. That the Catskill was in part deposited above sea level seems quite likely, however, and the delta model satisfactorily explains the rock distributions on a regional scale.

From study of the sedimentary features of the Upper Devonian section in the Appalachians, Rich (1951) concluded that the rocks of the "Portage" facies contain delta bottomset, foreset, and topset beds on a local scale. Although the postulated interrelationships of these three environments are only locally demonstrable and the recognition criteria are too general to be of great value, the study was significant in that the presence of a depositional slope was recognized. Subsequently, students of these rocks have exploited the theoretical relationships between paleoslope and flow direction of gravity-driven currents to infer the strand-line orientation. From the predominant east to west transport indicated by sole marks in the "Portage" facies, McIver (1960, 1961) postulated a strand-line paralleling the present Atlantic coast. Frakes (1961, 1963) suggested that relatively shallow water lay to the south of the Valley and Ridge Province in Pennsylvania during the Late Devonian because gravity-driven currents moved north-northwestwardly.

Sutton (1957) suggested that gross lithofacies patterns in the Upper Devonian rocks in the Appalachians might result from deposition in two en echelon troughs oriented northeast-southwest.

THE PALEOSLOPE

Evidence for a Paleoslope

The lines of evidence for a paleoslope come from several considerations. Most significantly, common graded bedding in the Trimmers Rock Member of the Fort Littleton Formation indicates that the depositing currents were closely controlled by bottom configuration. Graded bedding forms by the settling of particles from suspension. The moving water-body is therefore a type of suspension current in which the motive force results from density contrast with the surrounding envelope. The current moves in response to gravity and its own momentum, and in a direction strongly dependent on bottom configuration if velocity is low. Since such a current tends to seek the bathymetrically low areas, the conclusion that regional flow is parallel to the direction of slope seems justified.

The existence of the paleoslope is also indicated by other structures which originated through gravity. Bolster structures and angular blocks in many examples give evidence of downslope movement due to gravity sliding and viscous flow. The lowest stratigraphic position of these structures roughly marks the juncture between sediments deposited on the slope and those deposited on the floor.

The regional thickening and coarsening of most siltstone units toward the southeast suggests that a paleoslope existed late in the depositional history of the Trimmers Rock even if such a feature was not initially present. Moreover, the lower stratigraphic position of the base of the Catskill red beds toward the southeast insures that shallow water lay in that direction.

Orientation of the Paleoslope

Barrell (1913), largely on the evidence provided by rock distributions, postulated a paleoslope from southeast to northwest for the Upper Devonian of the central Appalachians, and regional lithofacies maps (Sutton, 1957; Jones and Cate, 1957; Ayrton, 1963) clearly show coarsening and thickening of the Upper Devonian toward the south in eastern Pennsylvania. McIver (1960, 1961) utilized sedimentary structures to infer a paleoslope from east to west for the "Portage" facies, from the east-southeast for the "Chemung" facies, and from the southeast for the Catskill Formation. It is difficult to conceive how this arrangement can be made to fit either the lithofacies trends or the north-south strand-line postulated by McIver.

Several facts derived from integrated stratigraphic and paleocurrent studies undertaken here suggest that a regional paleoslope was inclined from south-southeast to north-northwest in eastern Pennsylvania:

1) Stratigraphic relationships between the Catskill and the Trimmers Rock (Plate 1) show that the shallow-water Catskill facies occupies successively lower stratigraphic positions toward the south-southeast;
2) Individual siltstone units within the Trimmers Rock thicken toward the south-southeast (Figures 5-13);
3) Individual siltstone units within the Trimmers Rock coarsen toward the south-southeast (Figures 51-55). Massive conglomeratic sandstones occur only in the extreme south-southeast.
4) The mean-flow direction of gravity-driven currents as deduced from ripple marks is from the south-southeast for Type I beds in eastern Pennsylvania (Figure 63).

The close agreement between mean current direction deduced from sole marks in Type II beds (269°) and in Type I beds (279°) suggests that the same bathymetric feature, perhaps the base of a slope, controlled the direction of flow for both types of currents. Thus, most Type I currents moved generally northward in their early history, as indicated by ripple mark orientation, and were deflected at the foot of the slope to the westward course required by sole marks. Type II currents, originating farther to the east, traveled along the base of the slope toward the west, and in the area of this study, flowed parallel to deflected Type I currents. This pattern may be repeated in other portions of the delta (Figure 66).

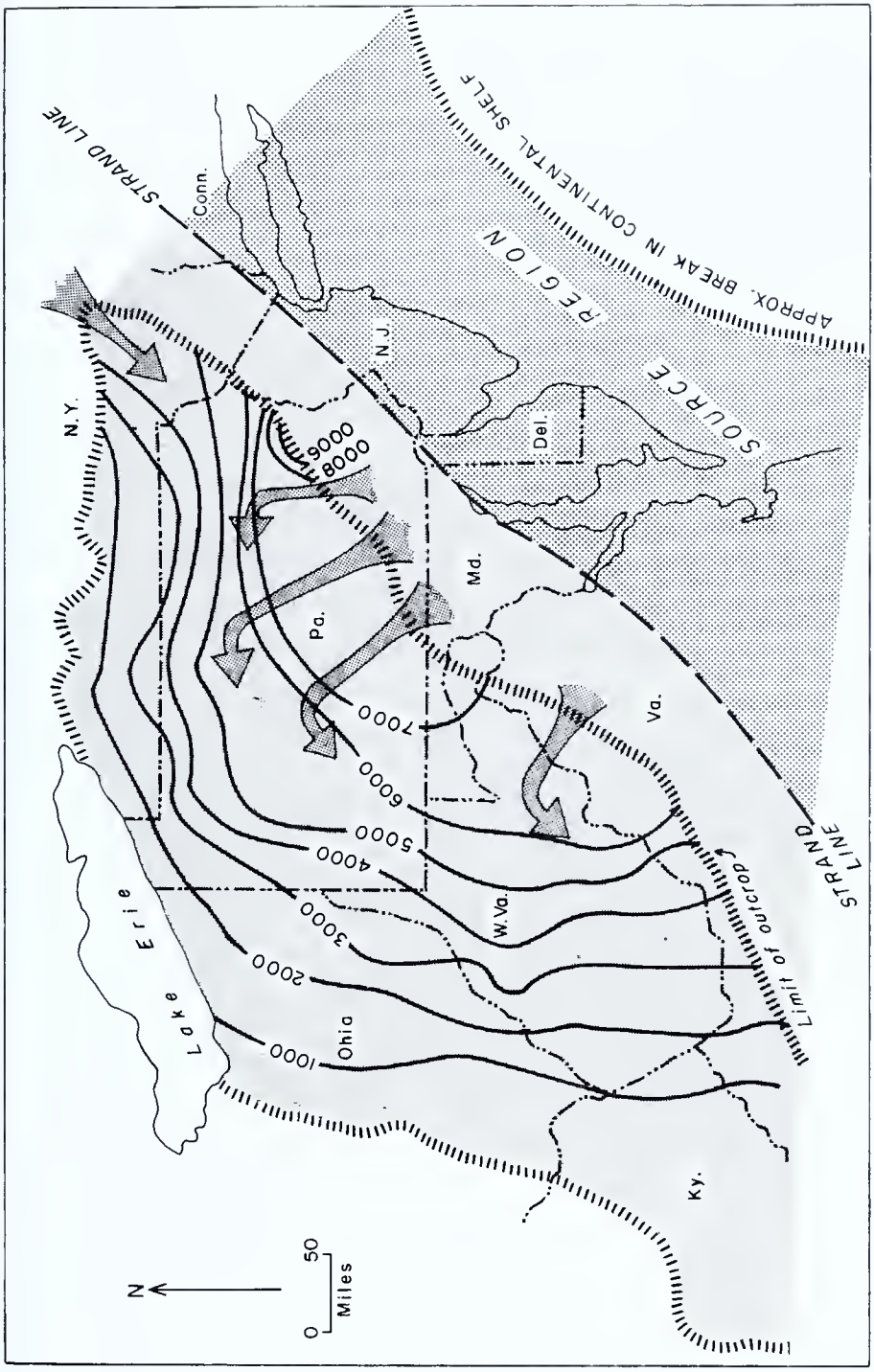

FIGURE 66. Paleogeographic reconstruction of the Catskill delta. Strand line at beginning of deltaic development. Isopach lines outline later form of the delta. Arrows show predicted paleocurrent trends throughout the delta.

In south-central Pennsylvania, Type I currents initially flowed northwestwardly and some were possibly deflected in an analogous manner toward the southwest. It is suggested that a paleoslope roughly contemporaneous with the one described for eastern Pennsylvania was inclined from southeast to northwest in the south-central part of the state. Perhaps currents from eastern Pennsylvania actually moved westwardly along the foot of a continuous slope on the south into south-central Pennsylvania.

Migration of the Paleoslope

The well-known facies relationships in the Appalachian Middle and Upper Devonian sequence strongly indicate migration of depositional environments through time. In effect, the shallow-water Catskill strata built progressively seaward over deeper-water deposits of the Trimmers Rock. The foot of the paleoslope, representing the juncture between slope and bottom deposits migrated seaward through time.

Location of the foot of the slope is based on the occurrence of landslide deposits in the measured sections; the lowest such structure in a given section separates strata related to the slope from those deposited on the floor. Quite likely, the lowest observed structure does not accomplish this separation precisely, as some slides may have moved far out on the floor, and lower unobserved structures may be present but concealed; separation of these environments is intended to be generalized rather than specific.

The stratigraphic and geographic distribution of slide structures is shown on Figure 57. From these data, Figure 67 was constructed to show migration of the foot of the paleoslope. The heavy lines in Figure 67 represent the approximate position of the foot of the paleoslope for Siltstone Units 3 through 8. Because the data are plotted on a non-palinspastic base map the distances between lines are too small, but it is quite likely that the trend is valid. Folds in the Valley and Ridge Province are approximately parallel to this trend so that unrolling of the tectonic structure would merely increase the spacing. Siltstone Units 1, 2, 9, and 10 are not plotted because of insufficient data.

Through time the foot of the paleoslope migrated in a direction roughly parallel to N25W. The paleoslope is assumed to have maintained a nearly linear trend, chiefly by deposition from currents which moved along the foot and concentrated their loads in the low areas. The location of the foot of the paleoslope for Siltstone Unit 3 is nearly coincident with the southeastern limit of occurrence of Type II beds. This close agreement between two independent lines of evidence adds strong support to the sedimentary model presented.

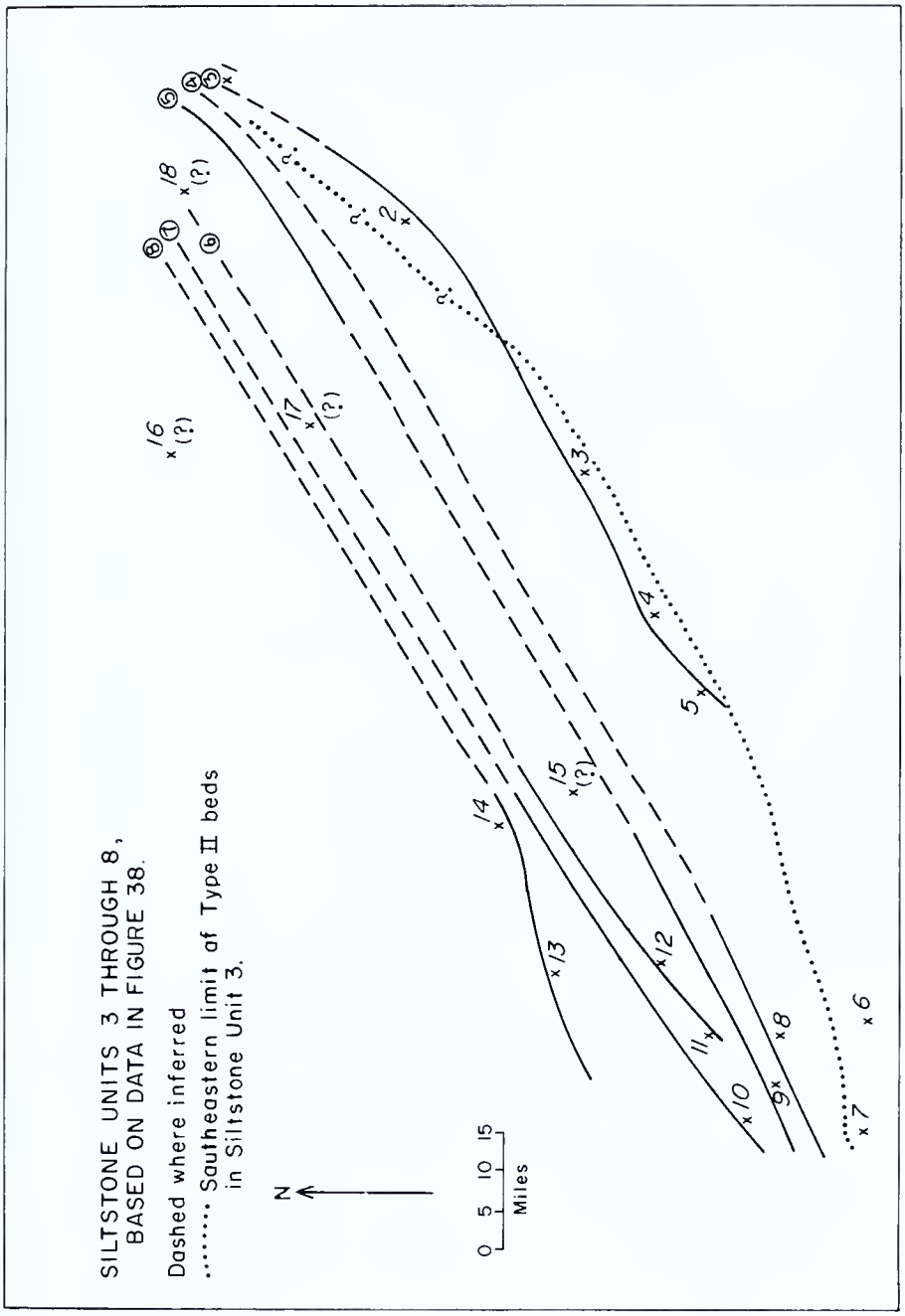

FIGURE 67. Migration of the foot of the paleoslope, Siltstone Units 3 through 8.

PALEO-ENVIRONMENTS

General

One of the principal methods of paleogeographic reconstruction involves delineation of paleo-environments. This may be accomplished by a number of different procedures, all of which are imperfectly developed at present, particularly for Paleozoic rocks. The classification of invertebrate faunal associations into paleoecologically significant groups (McAlester, 1960) gives most promise of yielding information bearing on paleogeographic reconstruction in rocks of the Catskill delta. In developing such a classification, however, strong consideration must be given to environmental clues offered by the rocks themselves even though sedimentary features are seldom truly diagnostic.

For the Trimmers Rock Member of the Fort Littleton Formation in eastern Pennsylvania, an indicative but not diagnostic characteristic is present in the guise of graded bedding. For these rocks graded bedding indicates deposition below wave-base, a somewhat speculative depth, and little more. On the other hand, most of the abundant fossils in the section are not good guides because they show evidence of having been transported and redeposited. The apparently in-place assemblages noted in Appendix A may ultimately provide answers to two extremely pertinent questions: 1) What were the environmental conditions in which gravity-driven currents moved; and 2) From which of several possible environments were fossils of the fragmental layers transported?

In the present study, two paleo-environments can be distinguished. These are the slope environment and the floor environment; they are delineated on the basis of the occurrence or non-occurrence of subaqueous landslide structures.

The Slope Environment

The rocks above the lowest observed slide structure are designated as deposits of the slope environment. Lithologic features of this rock suite are generalized in Table 5. With proper regard for geographic variation, which is considerable for most features, the following characteristics are deduced for the slope environment:

1. locally unstable slopes;
2. relatively high-energy gravity-driven currents;
3. high or frequent oxygenation;
4. relatively abundant epifauna;
5. widespread muddy substratum;
6. variable, but relatively shallow water. Intermediate neritic (?).

ENVIRONMENT	SLIDE DEPOSITS	LITHOLOGY		COLOR				ATTRIBUTES			SED. STRUCTURES			
		Rock Type	Sand Type	Red	Green	Brown	Gray	Fissility Type	Trace Fossils	Frag. Fossils	Ripple Mark	Sole Mark	Load Str.	Cross Lam.
SLOPE	Present	Shale > Type 1 >> Type 2 (rare)	Graywacke > Subgraywacke >> congl. sand.	A	A	C	C	Good to Fair	C	A	A	R	A	A
FLOOR	Not present	Shale > Type 2 ≈ Type 1	Graywacke >> Subgraywacke (rare)	R	R	C	A	Poor to Fair	A	C	R	C	C	C

TABLE 5. *Characteristic features of the slope and floor environments. Abbreviations: A—Abundant; C—Common; R—Rare*

The Floor Environment

The rocks occurring below the lowest slide structure are considered to represent sediments deposited on an essentially flat floor. The lithologic features for the floor environment are contrasted with those of the slope in Table 5. From these generalizations the following characteristics are deduced for the floor environment:

1. essentially flat floor;
2. relatively low-energy gravity-driven currents;
3. low or infrequent oxygenation;
4. relatively abundant infauna;
5. widespread muddy bottom;
6. relatively deep water. Deep neritic (?).

THE SOURCE AREA

The earliest attempts at paleogeographic reconstruction, summarized by Barrell (1913), concluded that a landmass of considerable size was situated to the southeast of the Late Devonian sea. The large volume of sedimentary rocks in the Catskill delta led these observers to conclude that at least part of this source area lay east of the present Atlantic coastline. However, King (1959, p. 60-62) points out that the difficulties inherent in postulating a foundering continental landmass include an unlikely transformation of the sialic crust to simatic material. Any reasonable discussion of the Catskill source area must take this problem into account.

Recent sedimentological studies in the Appalachian Paleozoic (Pelletier, 1958; McBride, 1962; Yeakel, 1962) have been unanimous in reiterating a southeastern source area for clastic rocks ranging in age from Upper Ordovician (Martinsburg Formation) to Lower Pennsylvania (Pottsville Formation). This source region possibly was centered on the present Piedmont Province. These studies have also succeeded in showing the existence of a paleoslope inclined toward the northwest and oscillating in position through the Paleozoic Era. The present investigation establishes that similar conditions prevailed during Late Devonian time.

As is the case with the strata of the Catskill delta, most clastic units in the central Appalachians thicken southeastwardly to the eroded limit of outcrop. Examples include the Martinsburg (McBride, 1962, p. 40), Bald Eagle and Juniata (Swartz, 1948, p. 22), Tuscarora (Yeakel, 1962, p. 1522), Bloomsburg (Hoskins, 1961), Montebello (Willard, 1939, p. 196), Pocono (Pelletier, 1958, p. 1038), and Pottsville Formations (Pelletier, 1958, p. 1060-1061). None of these units can be shown to be exclusively derived from a metamorphic and igneous terrain and several are known, in fact, to have originated largely from pre-existing sedimentary rocks (Pelletier, 1958, p. 1061; Yeakel, 1962, p. 1524). Only one angular unconformity, between the Catskill and Pocono

Formations (Trexler and others, 1961), is known from the clastic section, but disconformities occur between the Martinsburg and the Tuscarora (Stose, 1930) in south-central Pennsylvania, and between the Bloomsburg and the Oriskany (Swartz, 1939, p. 36) in eastern Pennsylvania.

Taken together, the stratigraphic thickening of many units toward the southeast and the occurrence of several unconformities in the southeast suggest that Paleozoic infilling of the Appalachian geosyncline took place through a process of "cannibalism." Thick wedges of clastic rocks accumulated near the source, but intermittent uplift through the Paleozoic repeatedly exposed these great thicknesses to erosion and redeposition. Undoubtedly, metamorphic and igneous rocks of the Piedmont Province contributed heavily to these clastic wedges, particularly the early ones, but evidence of this is scanty even in the near-source areas.

The Middle and Upper Devonian section of the Catskill delta shows evidence of derivation from a largely sedimentary terrane. Clasts in the conglomerates are overwhelmingly vein quartz; undoubted metamorphic or igneous clasts are rare in the rocks of the Catskill delta. The Skunnemunk outlier in northern New Jersey (Darton, 1894, p. 371) possibly represents a near-source deposit; clasts in this coarse conglomerate are predominantly quartzite and vein quartz. Buttner (1965) reports igneous and metamorphic clasts in the Catskill Formation of eastern New York. The notable scarcity of feldspar and lithic fragments other than shale in the graywackes of the Trimmers Rock indicates that any crystalline terrane in the source region was well removed from the strand-line. Additionally, the fine-grained nature of the Trimmers Rock is in accord with the hypothesis of a sedimentary source area.

A likely source for the sediments of the Catskill delta would be a broad subaerial slope occupying the present site of the southeastern Great Valley, the northwestern Piedmont, and possibly a portion of the Coastal Plain. This region was underlain by non-marine and marine clastic sediments possibly ranging in age from Late Ordovician to Middle Devonian. Southeast of this area but within the limits of the present continent, the crystalline rocks of the Piedmont were exposed in higher elevations and shed debris most of which accumulated nearby.

THE CATSKILL DELTA

The rocks considered in this study constitute a portion of the Catskill delta, remnants of which are exposed as far south as southwestern Virginia and as far north as central New York. The form of this structure is delineated quite clearly by isopachs and lithofacies lines on Figure 68. A principal objective of this study is to fit the Pennsylvania segment of this delta into what is known of the whole structure. Once this is accomplished, perhaps it will be possible to predict trends in other areas lacking in detailed study, and to look for similar relationships elsewhere in the geologic column.

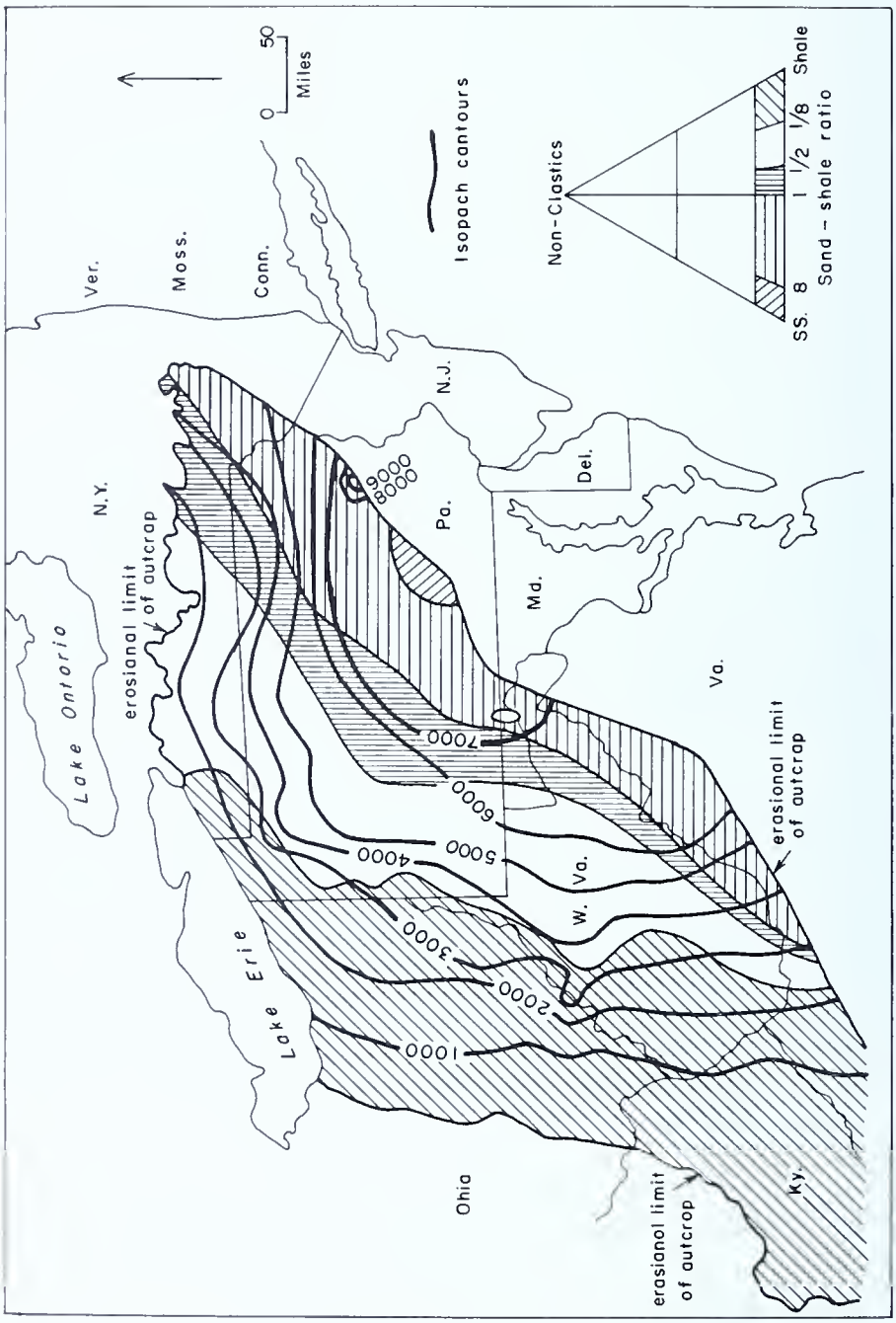

FIGURE 68. Isopach and lithofacies map of the Upper Devonian of northeastern United States. *Modified after Ayrton, 1963.*

Isopach and isolith trends for the Trimmers Rock in Pennsylvania show close parallelism with isopach and clastic ratio lines of the total Upper Devonian. This is demonstrated when Figure 68 is compared with Figures 4-13 and 51-55. Since paleocurrents in central and eastern Pennsylvania travelled both normal and parallel to these trends, the probability is good that paleocurrents in the Ohio-West Virginia region moved both from east to west and from north to south. Additionally, it might be expected that paleocurrents having a strong northward component of flow were instrumental in depositing many of the strata of central New York. Sutton (1957) has already shown that the Cashaqua Formation was deposited from the southeast.

It may be anticipated that the depositional conditions deduced for the area of this study apply as well to rock-units of similar lithologic aspect throughout the Catskill delta. Hopefully, the foot of the paleoslope may be delineated from eastern New York to southwestern Virginia, in which case it will perhaps tend to parallel the trends of the isopach and clastic-ratio lines of Figure 68 as in Pennsylvania.

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APPENDIX A

MEASURED SECTIONS

Sections measured in this study were chosen primarily on the basis of completeness of exposure. A few of the sections studied, notably those at Bush Kill and Dromgold, contain long covered intervals and hence were contrary to the general method of selection. Such sections were chosen because they provide the only information available in large areas or because they lie in areas of marked stratigraphic change. Several available sections were not measured because they are in close proximity to better-exposed sections, others because they contain extremely long covered intervals, and still others because of structural complications. The well sections (sections 15, 16, 17, and 18), generously made available by W. R. Wagner from his own sample descriptions, are not contained in this appendix but are summarized on Plate I.

FORMAT OF THE TABLES

Appendix A consists of tables rather than lengthy lithologic descriptions in an effort to make presentation of the data more compact. Detailed location information for each measured section is given on the page preceding the section description. Specific abbreviations and symbols used in the tables are explained on the page preceding Section I.

Each table, consisting of one or more pages, represents the measured section at the locality indicated by the heading at the top of the page. The tables are divided into a number of rows, each representing one measured unit, except where several rows are utilized to give information in the Miscellaneous column. Every fifth row bears the number of the measured unit to which the data of the row applies.

The 19 columns of the table provide a method of listing the observed characteristics for each measured unit. Headings at the top of the tables describe the information listed in each column; the general nature of this information is discussed in the following remarks.

Under the heading "Unit No." is given the number of the unit described in the row. Unit number 1 is the first unit below the lowest observed red Catskill shale or the lowest occurrence of the Delaware River Flags, whether this is a covered interval or not. Successive units, including covered intervals, are numbered consecutively, although only every fifth one, for purposes of clarity, is marked in the table. The third column, "Total Thickness" records cumulative thickness of the section totaled from the top of unit 1 and including all covered intervals.

Under "Color" letter designations (see page of abbreviations) of the appropriate color suites are given for each unit. In the case of multiple entries for one unit, the colors are given in order of abundance.

"Grain size" column 5, contains the estimated mode of grain size of the coarser beds in the unit. The entry "silty" is utilized to designate units of silty shale when coarser beds are not present. Additional grain size notations are given on the page of abbreviations.

The next four columns are headed "% Lithology" with sub-headings for Type I, Type II, Type III beds, and shale. Entries in these four columns represent estimated amounts of each rock-type, the figures necessarily totaling 100% for each unit. The following three columns, 10, 11, and 12, contain estimates of average bed thickness for Type I, Type II, and Type III beds in each unit.

Column 13, under the heading "Fissility" contains the number 1, 2, or 3 depending on the character of fissility in shale of the unit. Fissility designation 1 relates to well-developed fissility, designation 3 to poorly-developed fissility, and designation 2 to fissility of intermediate character. The notation "ptg." is listed for those units where shale occurs only as thin partings.

In column 14, headed "Fossils" qualitative estimates of the abundance of fossil-fragment layers where present in a unit are given by numbers 1 through 4. Designation 1 refers to relatively abundant layers, 2 to very common, 3 to common, and 4 to rare occurrences.

In column 15, two entries are made. The first, relatively uncommonly used, refers to the presence of distinctive large trace fossils (L), and the second applies to the more abundant smaller trace fossils (S).

Column 16, "Cross Bedding" contains estimates of the abundance of cross bedding where present in a unit. Again, grades of abundance are indicated by use of the numbers 1 through 4, 1 being abundant, 2 very common, 3 common, and 4 rare.

Column 17 is marked with an X if loaded structures are present.

Column 18, "Mvt." is marked with an X if evidence of lateral movement of pillows and angular blocks is present. Type of evidence for each occurrence is given in the Miscellaneous column. Some indefinite examples are marked with a query.

Under "Misc.," general remarks are made about the unit. Abbreviated terms are commonly used as a space-saving device; they are defined in the list of abbreviations. Notation of unusual lithologic features which are not covered by the preceding columns are included in this column. Boundaries of the major rock-stratigraphic units are indicated, and cultural features of the measured section are also listed in order to facilitate retracing of the section.

LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviations

abund.	abundant	N.	north
ang.	angular	O.T.	overturned
argill.	argillaceous	opp.	opposite
bdg.	bedding	P.P. (Pwr. pole)	power pole
bldg.	building	peb.	pebbles
blk.	block	ptg.	partings
calc.	calcareous	qtz.	quartz
cgl.	conglomerate	R.R.	railroad
cgltic.	conglomeratic	S.	south
char.	charcoal	sec.	secondary
cleav.	cleavage	sh.	shale
cont.	continued	sl.	slight or slightly
conv. bdg.	convolute bedding	sph.	spheroidal
cor.	corner	stain.	staining
cov.	covered	str.	stream or strong
crink.	crinkled	struct.	structure
discont.	discontinuous	tect.	tectonic
dk.	dark	traf.	traffic
E.	east	vert.	vertical
fiss.	fissility	W.	west
foss.	fossils in place	weath.	weathered
frag.	fragments	wt.	white
gran.	granules	yel.	yellow
gy.	gray		
intersect.	intersection		
irreg.	irregular		
isol.	isolated		
lam.	laminated		
lentic.	lenticular		
lg.	large		
lt.	light colored		
max.	maximum		
med.	medium		

Symbols

⊥	attitude of stratification
<	less than
>	more than
?	questionable
№	number

Grain Size: cs—coarse silt, vf—very-fine sand, f—fine sand, m—medium sand, c—coarse sand, silty—silty shale

Color Suite Designations

A. . . .Blacks (N 1, N2).
B. . . .Dark Grays (N3, 5 B 3/1).
C. . . .Medium Grays (N 4, N 5, 5 B 5/1, 5 B 4/1, 10 YR 4/2).
D. . . .Light Grays (N 6, N 7, 5 Y 5/2, 5 GY 6/1).
E. . . .Very Light Grays (N 8, 10 Y 6/2).
F. . . .Dark Olive Greens (10 Y 5/4, 10 Y 6/6, 5 GY 5/2, 5 GY 3/2).
G. . . .Light Olive Greens (5Y 6/4, 10 Y 7/4, 10 GY 7/2).
H. . . .Dark Browns (5Y 4/4, 5 YR 4/1, 5 YR 5/2, 5 YR 4/4, 10 YR 4/2).
I . . . .Light Browns (5 YR 7/2, 5 YR 6/4, 5 YR 6/2, 10 YR 6/6).
J . . . .Reds (10 R 5/4, 10 R 4/6, 5 YR 3/4, 5 RP 4/2).
K. . . .Yellows (5 Y 8/4, 5 Y 7/6).

Section 1, Port Jervis, N. Y.

Much of the Middle and Upper Devonian section is exposed along the Delaware River in Pike County, Pennsylvania and Orange County, New York. These exposures occur on the Port Jervis North 7½-minute quadrangle.

A section of flaggy sandstones with negligible amounts of shales overlies the highest strata of Trimmers Rock lithology north of a point 2100′ south of 41°25′00″N and 2300′ east of 74°45′00″W on the river bank in the village of Millrift, Pennsylvania. The Trimmers Rock dips gently northwest and is exposed from this point south along the west bank of the river. Much of the exposure south of the railroad bridge is accessible only by boat or wading. South of a point 10,500′ north of 41°22′30″N and 2600′ east of 74°45′00″W, the section is concealed on the Pennsylvania side of the river.

At a point about 5500′ north of 41°22′30″N and 2400′ east of 74°42′30″W on the bluffs bordering the river on the New York side, the next lower exposures of the Trimmers Rock are located. The interval between the two points described occupies about 700 feet of section which is nearly entirely concealed.

The measured section traverses a paved road down the river bluff through a series of switchbacks to Routes 42 and 97 below. Parts of this section are covered and others are duplicated because of topographic relief. Road-cuts along Routes 42 and 97 south to the northern outskirts of Port Jervis reveal sandstones and siltstones of bedding Type I interbedded with a more dominant type of siltstone which is dark gray, very poorly bedded, and cut by prominent joints dipping steeply to the southeast. The latter rocks are considered to have the lithologic characteristics of the Mount Marion Formation. At the northern limit of the town, Mount Marion siltstones lie in sharp contact on 126 feet of dark-bluish-gray shales.

Strata of Mount Marion lithology at the base of the section are listed in the columns for Type II beds, and the columns are therefore sub-titled "M.M."

Stratigraphic Description — PORT JERVIS SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscelloneous
	16		G	f														Delaware
																		River flags
																		N.bank at
																		Millrift
1	10	10																covered
	1½	11½	DC	cs-f	100				?									small hut
	3	14½	DC	"	80			20	14			3					x	broken bed
	2½	17	DC	"	40			60	14			1				x		
5	1½	18½	DC	"	80			20	7			1						
	4½	23	C	"	10			90	5			2				x		
	1½	24½	DC	"	100				4							x		
	3½	28	C					100				1						
	1	29	D	cs-f	100				12?						2	x		4" sets (CB)
10	5	34	C					100				1						
	½	34½	D	cs-f	100				3							x		
	6	40½	DC	"	10			90	9			1						isol. foss.
	1½	42	D	"	85			15	10			1				x		
	9	51	DC	"	10			90	8			2						
15	5½	56½	DC	"	25			75	8			2				x		
	3	59½	D	"	90			10	8							x		
	5	64½	DC	"	10			90	3			1						
	2½	67	DC	"	25			75	4			2	4					clay galls
19	8	75	D	"	10			90	3			2						on river
																		bank, 50' N.
																		of "Y" in
																		road
20	75	150																covered
21	5½	155½	DC	cs-f	25			75	7			2						W.end RR.
																		cut
22	3	158½	C					100				1						N.60E.10N. ±
	7	165½	DC	cs-f	60			40	6							x	x	eroded base
	14	179½	DC	"	40			60	6½			2						
25	17	196½	DC	"	40			60	9			3						roadway
																		bridge, 91
																		milepost RR
26	7½	204	DC	cs-f	10			90	3			2						RR. cut
	9½	213½	DC	"	10			90	2			1				x		river bank
	7	220½	D	"	60			40	?							x	?	
	12	232½	D	"	20			80	2			2				x		
30	2½	235	D	"	75			25	4			3				x	x	eroded base
	7	242	D	"	50			50	6			1				x		
	25	267																covered
	6	273	DC					100				3						irreg. fiss.
34	5	278	D	cs-f	75			25	6			3			2			bridge
																		abutment
35	4	282	DC	cs-f	70			30	3½			2				x		

Stratigraphic Description					PORT JERVIS SECTION													
Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscelloneous
					I	II	III	Sh	I	II	III							
36	6½	288½	DC	cs-f	15			85	2			3						
	1½	290	D	"	90			10	6			2						clay galls
	6	296	D	"	75			25	4½			3						
	3	299	D	"	60			40	5½			2				x		
40	7½	306½	DC	"	25			75	2½			2						
	4	310½	C	"	10			90	4			2				x		
	2½	313	C					100				1						
	2½	315½	DC	cs-f	65			35	3½			1				x		
	4	319½	DC	"	55			45	3			1						
45	3½	323	DC	"	25			75	3½			1						
	5	328	DC	"	75			25	3			3						
	2	330	D	"	60			40	10			2				x		
	4½	334½	DC	"	25			75	4			2				x		
	6	340½	D	"	15			85	2½			1			2	x		plant frag
50	1	341½	D	"	60			40	4			2				x	?	
	1½	343	D	"	90			10	20			3			2	x		
	20	363	D	"	25			75	5			2						
53	10▲	373	D	"	80			20	2½			1						"elephant feet" out-crop along bank
54	30▲	403																covered
55	10▲	413	D	cs-f	80			20	12			1						
56	40▲	453	D	"	25			75	3			1						
57	10	463	DC	"	85			15	16			1				x		end vert. cliffs
58	2	465	C	cs-f	10			90	1½			1						
	9	474	DC	"	90			10	30			3				x		
60	4½	478½	DC	"	75			25	9			3				x		
	7	485½	DC	"	10			90	2			1				x		
	15	500½	DC	"	55			45	20			3				x		
	9½	510	D	"	45			55	6			3				x		
	2	512	D	"	90			10	18?			3				x		
65	2½	514½	D	"	20			80	3			2						
	5	519½	DC	"	70			30	6			1	1					
	8½	528	D	"	60			40	5			3				x		
	4½	532½	D	"	45			55	3½			2				x		
	4½	537	DC	"	90			10	3			3				x	?	eroded base
70	10	547	DC	"	60			40	2			3		S				
	7	554	CB				10	90			1	1			2			
	10	564	DCB	cs-f	70			30	3			1					x	eroded base
	22½	586½	CB	"	15		10	75	3		1	2			3	x		
	4½	591	CD	"	60			40	2½			1				x	x	eroded base
75	4	595	CB					100			-	1						
	3	598	CD	cs-f	85			15	4			1				x		
	7	605	CD	"	20			80	2½			2						thins to N.

▲Estimated

Stratigraphic Description — PORT JERVIS SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
78	4	609	CD	cs-f	90			10	6			1			2	x		thins to N.
79	4	613	CD	"	70			30	7			1		s				
80	3	616	CD	"	75			25	3½			2		s				
	11	627	CD	"	35			65	2½			2						thins to N.
	3½	630½	CD	"	70			30	10			3				x		
	6	636½	CD	"	60			40	2½			3						
	4½	641	CBD	"	80			20	9			1						
85	7	648	B		100				?									isol. foss.
																		end outcrop
86	700	1348																covered
87	6	1354	B	cs-f	80		20		3		1							top of bluff
																		E. side river
88	4½	1358½	B	cs-f	95			5	3			3				x		road cut
	4	1362½	B	"	75			25	5			3		s		x		
90	2½	1365	B	"	25		35	40	7		1	3						
	3	1368	B	cs	85		15		?		1					x		
	3	1371	B		75	tr.		25	2			3		s				
	5	1376	CB	cs-f	85			15	?			3				x		
	4	1380	CB	"	80			20	4							x	x	eroded base
95	4	1384	B			tr.		100				1						
	102	1486																covered
	3	1489	CD	cs-f	95			5	2			3						road-cut
	3	1492	CBD	"	40	tr.	20	40	3		3/4	1				x		N.50E.16N.
	2	1494	BC			MM		100		MM								silty
100	3½	1497½	CBD	cs-f	45	10	25	20	3	2	1	2						clay galls
	71	1568½																covered
	4½	1573	CD	cs-f	100				40									
	13½	1586½	BC			tr.		100				3						silty
	2½	1589	CD	cs-f	90			10	24			1				x		
105	7	1596	CBD	"	80			20	20			3				x	?	
	14	1610	B			tr.		100				3						
	8	1618	CD	cs-f	95			5	24			1				x		
	5	1623	D	"	100				12?							x		
	2½	1625½	CB			tr.		100				3				x		
110	2	1627½	D	cs-f	100				7?									
111	3	1630½	D	"	95			5	12			3				x		
																		next out-
																		crop in
																		cut is
																		up-section
112	160	1790½																covered
	3	1793½	D	cs-f	100				10							x		road-cut
	2	1795½	CB			tr.		100				3						
115	1½	1797	D	cs-f	100				16							x		
	2½	1799½	CB					100				3						
	2½	1802	CBD	cs-f	80			20	18							x	?	

Stratigraphic Description					PORT JERVIS SECTION														
Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
	1½	1803½	CB				MM	100			MM	3						
119	3	1806½	CBD	cs-f	70			30	10							x	?	eroded base
120	1	1807½	CB	"	90			10	4				1					ironstain
	2	1809½	D	"	100				8									
	2	1811½	B	"		tr.		100				1						
	4½	1816	CB	cs-f	30	tr.		70	3			3				x		
	5	1821	CBD	"	70			30	6			3				x		
125	5½	1826½	CBD	"	70	tr.		30	6			2				x		clay galls
	11½	1838	CD	"	60			40	9			3				x	x	O.T.Pillows
	1½	1839½	D	"	100				18									irreg.base
	4½	1844	CB	s			30	70			2½	2			2			
	2	1846	B					100				2						
130	2½	1848½	CD	cs-f	80			20	30			3				x		
	1	1849½	B					100				1						
	2	1851½	CB	cs			85	15			2	2						
	3½	1855	D	f	80			20	7							x	x	ang.blocks
	14	1869	CD	cs-f	15			85	6			2						
135	4	1873	CD	"	80			20	7			2				x		
	6	1879	CD	"	10			90	1½			2			4	x		
	48	1927																covered
	7	1934	CB	cs	15	tr.		70	13			1						road-cut
	2½	1936½	CB	cs-f	100				15									N.50E.16N.
140	3	1939½	CB					100				1						paper shale
	242	2181½																covered
142	10	2191½	C	s			85	15	-		4	2						Routes 42
																		& 97 at "Y"
																		intersectio
143	4½	2196	C	cs-f	75			25	4½			1	3			x		road cut
	5	2201	C	"	5	tr.		95	1½			2						
145	2	2203	CD	cs			90	10			5	1				x	x	eroded base
	14	2217	C	cs-f	10	tr.		90	9			3	4					
	13½	2230½	CD	"	90			10	8			1				x		P.P. 25351
	7	2237½	CB	"	90			10	12			3		s		x	x	eroded base
	9	2246½	CBI	"	10	tr.	20	70	2		?	2		s				
150	1½	2248	CBI	cs			95	5			4	2				x		
	1½	2249½	CBI	"			70	30			6	3				x		
	4½	2254	CBI	"			20	80			?	2				x		
	9½	2263½	CI	"			25	75			7?	2	4		2	x		P.P.25352
	13	2276½	CI	"			70	30			?	2	4			x		argill.
155	12½	2289	CBI	"			50	50			11	2				x		P.P.25353
	12	2301																covered
	1½	2301½	CI	cs-f	90			10	6			2		s				
	8½	2311	CBI	cs			90	10			1½	2						argill.
	8½	2319½																covered
160	9½	2329	CBI	cs			95	5			2½	2				x		str. cleav.
	11	2340																covered

Stratigraphic Description — PORT JERVIS SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
	5½	2345½	CBI	cs-f	65			35	10			2				x		
63	6	2351½	CBI	"	15			85	8?			2				x		
64	14	2365½	CI	cs			95	5			?	2				x		str.cleav.
65	11	2376½	CBI	"			70	30			?	1						argill.
	12	2388½	CI	cs-f	20		70	10	1½		1½	1			3	x		
	7	2395½	D	cs-f	15		65	20	1½		1½	2			3			
	3	2398½	DI	cs			100				?					x		
	5	2403½	DI	"			90	10			3	2			4			4" sets
70	70	2423½	BD	"			100				?							
	14½	2438	B	silty				100				3	4					abund.pyrite
	1	2439	CB	cs			90	10			3½	1	1					laminated
73	30½	2469½	B	silty	5			95	1½			3	4					"Park Ave" plaque
74	33½	2503	BC	cs			10	90			1	2				x		str.cleav.
75	19	2522	DI	cs			95	5			?	1						N.55E.24N.--
76	126	2648	AB		tr			100	1			1						siderite nodules. Foot of hill, end road-cut

Section 2, Bush Kill

Good exposures of the upper portion of the Trimmers Rock occur in the rugged terrain bordering Bush Kill in Middle Smithfield Township, Monroe County. The highest rocks exposed in the vicinity are massive gray sandstones, platey siltstones, and red shale along Route 402, ½ mile south of Ressaca Falls Boy Scout Camp. Between this point and the exposures measured, interbedded Trimmers Rock and massive Delaware River sandstones are poorly exposed in several gentle folds which make it difficult to determine thickness. It is likely, however, that less than 300 feet of section lies between the section measured and the red shales of the Catskill.

The measured section begins at the top of a high knoll on the east bank of the Kill 7800′ south of 41°07′30″N and 2800′ east of 75°05′00″W, on the Bush Kill 7½-minute quadrangle. Below the lowest measured unit along the Kill at 5700′ north of 41°05′00″N and 4200′ east of 75°05′00″W, outcrops are sparse and no attempt was made to measure the section.

Stratigraphic Description — BUSH KILL SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscelloneous
																		Top of high bluff along E.side Kill
1	9½	9½	CB	cs-f	10			90	1½			1						65E.11N.
	19½	29																covered
	6	35	B	cs-f	15			85	5			1						
	1	36	B	"	90			10	10			3				x		
5	16	52	CBD	"	30			70	4			1		s				
	1	53	CB	"	80			20	9			1				x		
	3½	56½	CBD	"	20			80	4½			1						
	9	65½	CBD	"	25			75	4			1						
	5	71½	CBD	"	40			60	5			1						
10	8½	80	CBD	"	20			80	2			1			4			
	7	87	CBD	"	30			70	3½			1						argill.
	14½	101½	CD	"	65			35	10			1			2	x		
	2	103½	D	"	50			50	14			1				x		
	2	105½	C	"	20			80	1			1						
15	3½	109	DC	"	40			60	5			1				x	?	flow struct?
	10	119	CD	"	40			60	6			1						hill side
	3	122	CD	"	75			25	9			1				x	x	eroded base
	2½	124½	C					100				1						
	5	129½	D	cs-f	95			5	10			3				x	x	eroded base
20	6	135½	CD	"	25		10	15	2½		3/4	1	4		4			
	1½	137	C					100				1						
	1½	138½	D	cs-f	90			10	9							x		
	3	141½	C					100				1						silty
	1	142½	D	cs-f	100				12							x	?	
25	2	144½	D	"	100				?							x		
	3½	148	D	"	85			15	6			1				x	?	
	1	149	D	"	100				7									
28	7	156	C	"	25			75	8			1			3			base bluff
																		cont.in str.
																		bed to S.
29	4	160	CBD	cs-f	20		5	75	5		3/4	1						
30	15½	175½	CBD	"	15		5	80	2½		1	1				x		
	18½	194	CB	"	30			70	3			1						
	3	197	CB	"	40			60	3½			1						
	3	200	D	"	90			10	30			3				x		
	17½	217½	CBD	"	25			75	4			1						
35	2	219½	CBD	"	95			5	14			1				x		
	2	221½	CB					100				1						
	12	233½																covered
	9	242½	CBD	cs-f	15			85	3			1						75E.17N.
	4½	247	CBD	"	30			70	4			1						
40	5	252	CB	"	10			90	3			1						
41	10	262	CBD	"	75			25	7			1						

Stratigraphic Description — BUSH KILL SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscelloneous
42	8	270	CBD	cs-f	60			40	6			2						
	7½	277½	CBD	"	80			20	14			1						
	4½	282	CBD	"	25			75	7			1						
45	4	286	CB	"	95			5	20			1				x		
	22½	308½	CBD	"	65			35	10			2				x		
	11½	320	CBD	"	40			60	4			2						
	7	327	CB	"	90			10	12			3				x		
49	13	340	CB	"	75			25	10			2						E.side kill cont. along E.side kill
50	16	356	CD	cs-f	80			20	14			1				x		45E.17N. ⊥
	3	359	C	"	20			80	9			3						
	2	361	CD	"	95			5	18			1				x		
	5½	366½	CB	"	30			70	3			2				x		isol.foss.
	3½	370	CD	"	80			20	10			3				x		
55	10	380	CBD	"	20			80	6			2		s		x		
	5½	385½	CBD	"	40			60	7			1				x		
	5½	391	CB	"	25			75	2½			2						
	4½	395½	CD	"	90			10	5			1				x		
	9	404½	CBD	"	15			85	4			2		s				isol.foss.
60	2	406½	CD	"	80			20	5			1				x		
	2½	409	CB					100				2						
	7	416	CBD	cs-f	60			40	7			2						
	6½	422½	CBD	"	70			30	9			2						
	6	428½	CBD	"	20			80	6			2						60E.16N. ⊥
65	8	436½																covered
	9	445½	CB	cs-f	15			85	5			2						
	8½	454																covered
	14	468	CBD	cs-f	20			80	8			2						
	10	478																covered
70	3½	481½	CD	cs-f	80			20	10			1						
	8	489½	CB	"	15			85	5			2		s				
	8½	498	CBD	"	75			25	8			1			4			
	5	503	CD	"	85			15	8			3						isol.foss.
	24	527	CB	"	20			80	4			3				x		
75	11	538	CB	"	10			90	7			3						isol.foss.
	15	553	CB	"	35			65	2			2						50E.14N. ⊥
	110	663																covered
78	41	704	B	cs			5	95			3/4	1						bend to E. in kill
79	27	731																covered
80	19	750	BC	cs														massive Mount Marion siltstones
																		65E.18N. ⊥

Section 3, Bowmanstown

Section No. 3 was measured along Routes 29 and 45 in Lower Towamensing Township partly in the Borough of Bowmanstown, Carbon County and on the Mauch Chunk 15-minute quadrangle. Other continuous sections are exposed in the vicinity: in cuts along the railroad below Routes 29 and 45; in railroad cuts north of Bowmans, East Penn Township, on the west side of the Lehigh River; and vertical beds in roadcuts north of Lehighton on Route 209. The section at Bowmanstown was selected because it is the most continuous and the least affected by structure. Widening of Routes 29 and 45 resulting in new high cuts through the Trimmers Rock and lower Catskill was begun in the summer of 1962, after measurement of the section was completed. The highway construction, while obliterating the measured exposure, has completely exposed the upper 95 percent of the section in new cuts.

The section as measured begins in north dipping Trimmers Rock at a point 9500′ south of 40°50′00″N and 1200′ west of 75°40′00″W and terminates at a point about 11,100′ south of 40°50′00″N and 1000′ west of 75°45′00″W.

Stratigraphic Description					BOWMANSTOWN SECTION													
Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscelloneous
					I	II	III	Sh	I	II	III							
	17		red		65			35				2						Catskill in road-cut, crest of rise
1	5½	5½	J	f	100				30?									
	10	15½	G	"	100				24									laminated
	9	24½	K	m-c	80			20	12			1	4					clay galls
	13½	38	I	f	85			15	18			3				x		15% covered
5	4	42	C	"	90		10		2½		½							70E.56N. ←
	19	61	GC	"	100				30?							x		plant frags
	10	71	DC	"	100				22							x		clay galls
	7½	78½	D	"	65			35	5			1				x		clay galls
	4	82½	DC	"	100				12							x		
10	3½	86	DJ	f-m	100				10									micaceous
	14	100	DC	m	90			10	?			1				x		clay galls
	13½	113½	G	f	20			80	1½			1						laminated
	50½	164																covered
	24	188	GC	f-m	100				16							x		sl. lam.
15	8½	196½	GC	f	95			5	4			1						argill.
	10	206½	GC	"	75		tr.	25	5½			2		s				
	13	219½	GC	cs-f	90			10	18			2				x		
	5½	225	C	cs			15	85			3/4	1			4			
	8½	233½	G	cs-f	75			25	4			2	4					argill.
20	21	254½	GC	cs	5		tr.	95	3			2						silty sh.
	12	266½	GC	"			25	75			1	2			4			
	6½	273	DC	cs-f	25			75	2½			1						
	18	291																covered
	4	295	DC	cs-f	100				20							x		
25	3	298	DC	"	90			10	4½			3		s				
	8	306	DC	f-m	85			15	15			2				x		
	5½	311½	C	cs-f	35	30		35	6	1						x		
	7	318½	DC	"	85	10		5	12	1						x	x	eroded base
	11	329½	C	cs			10	90			½	3	4		4			silty sh.
30	5	334½	C	cs-f	40			60	6			3				x	?	
	2	336½	C	"	55			45	2			1						
	3	339½	C	"	30			70	4			3				x		
	1½	341	C					100				2						
	4	345	DC	cs-f	20		15	65	2		1	3			4			silty sh.
35	2½	347½	D	"	100			PTG	30									
	3	350½	DC	"	35		15	50	1½		1	3						silty sh.
	4½	355	D	"	85			15	5½			1	3					
	5	360	DC	"	95		tr.	5	7			3	4		3	x		
	12	372	DC	"	20		10	70	3		1	3						silty sh.
40	10	382	DC	"	40			60	4			3				x	?	60% covered
	4½	386½	DC	"	70			30	3			1	2			x		
	3½	390	C	"	95			5	4			3	4					

Stratigraphic Description — BOWMANSTOWN SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
43	24½	414½	DC	cs-f	75			25	3			3	4		3			silty sh.
44	6	420½	C	"	20		20	60	2		1	3						
45	9	429½	C	"	95			5	9			3	4					laminated
	10	439½	C	"	20	55	10	15	4	2	½	3						
	1½	441	D	"	100				9				1					
	5	446	C			75	5	20		1½	½	3						
	5	451	C	cs-f	80			20	3½			3	1					
50	13	464	C	"	100			PTG	10?			3	2			x		
	4	468	C	"	90			10	5			3	2					
	16	484	C	"	95			5	16			3	3					
	4½	488½	DC	"	80			20	14			3	4			x		
	10	498½	C	"	35			65	3½			3				x		silty sh.
55	2	500½	C	"	10			90	4			2						
	7	507½	C	"	100			PTG	14			3						
	6½	514	C	"	80		tr.	20	6			3			4			
	5	519	C	"	100				?									sheared
	16½	535½	C	"	65			35	10			2						laminated
60	6	541½	C	"	100				70½							x		
	4½	546	C	"	50	30		20	3	1		3				x		
	9½	555½	C	"	95			5	14			3			4			
	9½	565	C	"	85			15	5			3	3					
	22	587	C	"	70	20		10	7	2		3	4			x		
65	4½	591½	C	"	90			10	4½			2						
	4½	596	DC	"	45			55	2½			2						
	3	599	DC	"	30			70	4			3						
	16	615	C	"	25			75	5			3						
	10	625	C	"	65			35	7			3						
70	8½	633½	C	"	90			10	10			3						
	13	646½	C	"	90			10	8			3				x	x	O.T. load-cast
	18	664½	DC	"	25			75	5			3						silty sh.
	4	668½	C	"	85			15	4½			3						argill.
	6	674½	DC	"	90			10	9			2		s		x		
75	4½	679	C	"	35			65	3½			2						
	6	685	C	"	90			10	7			1		s				
	26	711	CB					100				3						
	8	719	DC	cs	75			25	3			3						argill.
	8	727	DC	cs-f	90			10	10			2						argill.
80	6½	733½	DC	"	95			5	4			3				x		
	4	737½	DC	"	50			50	3			3						
	3½	741	CB					100				2						
	19½	760½	DC	cs-f	80			20	3½			3						argill.
	15	775½	C	"	20			80	4			2						argill.
85	12	787½	CB	"	5			95	2½			1						
	43	830½																covered
	7	837½	DC	cs-f	30			70	1½			1						65E.43N.

Stratigraphic Description — BOWMANSTOWN SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
	3½	841	C	cs-f	75			25	3			3						
89	5	846	C	cs		20		80		1		1						
90	5½	851½	DC	cs-f	35	10		55	2	1								
	2½	854	C	cs		40		60		1		1						
	4½	858½	C	cs-f	10	75		15	2½	2		1						
	4	862½	C	"	5	85		10	3	3½		1						
	2½	865	C	cs		90		10		1½		2						
95	3½	868½	C	cs-f	70	20		10	2	1½		2						
	3½	871	C	cs		90		10		1½		2						
	5	876	C	"		95		5		3		3						silty sh.
	4½	880½	C	"		90		10		1½		2						
	6	886½	C	cs-f	15	70		15	2½	1½		2						
100	4	890½	C	cs		90		10		2½		2						argill.
	5½	896	C	cs-f	5	75		20	3	1		1						
	6	902	C	"	20	70		10	3½	2½		3		s				argill.
	3	905	C	"	10	70		20	3	2		1		s				
	4½	909½	C	cs		35		65		1½		1						
105	11	920½																covered
	16	936½	C	cs		20		80		1		2						
	4½	941	C	"		50		50		1		1						
	7½	948½	C	"		35		65		1		2						
	11	959½	C	"		5		95		1		1						sph.weath.
110	4	963½	C	"		20		80		1½		1						
	7	970½	CB	"		10		90		1		1						
	9	979½	CB	"		15		85		1		1						
	9	988½	CB	"		25		75		1		2						
	5½	994	CB	"		40		60		1½		2						
115	6	1000	B					100				1						20% covered
	5	1005	B	cs		20		80		2		1						park area
	20	1025	B					100				1						sph. weath.
	17	1042	B	cs-f	10			90	2			1						
	9	1051	B					100				1						
120	6	1057	B	cs-f	20			80	1⅓			1						
	31	1088	B					100				1						top of Harrell
	23	1111	B					100				1						paper shale
	8	1119	B					100				1						70E. 45N.
	63	1182																covered
125	48	1230	B					100				2						
	45	1275	B					100				2						
	60	1335																covered
																		reentrant
	25	1360		limey				100				3						Tully
	32	1392		cs-f	80			20	4			2						
130	12	1404		"	70			30	3			2						massive (?)
	4	1408		cs-m	100				?									
132	40	1448		cs-f	10			90				2						

Section 4, New Ringgold

The Trimmers Rock Member of the Fort Littleton Formation is exposed in road-cuts along Route 443 in the Borough of New Ringgold, Schuylkill County on the New Ringgold 7½-minute quadrangle. The section as measured begins at a point about 4700′ south of 40°42′30″N and 2000′ east of 76°00′00″W. North-dipping reddish gray sandstones mark the base of the Catskill. Very-dark-gray shales which weather light gray occur at the base of the exposed section at a point about 6600′ south of 40°42′30″N and 200′ east of 76°00′00″W.

It is believed that the rocks below the measured section consist dominantly of shale because of subdued topography. A few hundred yards to the southeast of the base of the measured section, a road-metal quarry is cut in very-dark-gray to black shales showing snowball structure. These shales are highly similar to the Mahantango Shale in this region.

Stratigraphic Description					NEW RINGGOLD SECTION													
					% Lithology				Average Bedding Thickness									
Unit No.	Thickness	Total Thickness	Color	Grain Size	I	II	III	Sh	I	II	III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
	2½		red	silty				100										Catskill;
																		50' S.
																		culvert
	3																	covered
1	5	5	J	vf-f	95			5	10		PTG	2						
	104	109																covered
	10	119	DC	f	35			65	7			1						75W.28S.
	7	126	G	clay				100				1						syncline
5	4½	130½	I	f-m	100				18									argill.
	5	135½	I	f-m	90			10	10		PTG	1				x		clay galls
	2½	138	GC	clay				100				1						
	3	141	GD	f-m	95			5	8		PTG							laminated
	1	142	GD	clay				100				1						
10	16½	158½	GD	clay			tr.	100				2						argill.
	3½	162	D	m	100				14									laminated
	4	166	D	f-m					7									pyrite
																		stain
13	8	174	D	f-m	100				12									cgl.wt.qtz.
																		peb.3" max.
14	11	185	D	f	100				7						4			laminated
15	5½	190½	GC	clay				100				1						
	6½	197	GD	f-m	100				6									sl.cgltic.
	4½	201½	D	m-c	100				4½						2			cgl.,qtz.<½
	10	211½	GD	rf-m	100				5									sl.cgltic.
	3	214½	GC	rf-m	60			40	15			2						argill.
20	6	220½	GC					100				1						
	5	225½	GC	m-c	95			5	9			1						cgltic.<½"
	1½	227	GD					100				1						
	4½	231½	GD	f	100													massive (?)
	2½	234	GC					100				1						
25	2	236	DI	f	65			35	4			1						
	6½	242½	DI	vf-f	95			5	9		PTG	1				x		laminated
	6	248½	GC	f	20			80	3		PTG	2						
	4	252½	GC	f	80			20	8½			2				x		lentic.beds
	4	256½	GC	f	25			75	3½			1						silty sh.
30	4	260½	C	f	100											x	?	
	7	267½	GC					100				1						
	5	272½	GC	vf-f	15			85	10			1						argill.
	7½	280	GD	vf-f	25			75	5							x	?	snowballs
	18	298	GD	vf-f	10	5		85	2½	1½		2						culvert
35	4½	302½	GDC	vf-f	15			85	4			2						str.joints
	6½	309	GC					100				2						
	2	311	DI	cs-f	90			10	6			1	3			x		
	7½	318½	DI	"	10			90	4			2						
	11½	330	DC	"	70			30	6			2				x	x	eroded base
40	9	339	DC	"	60			40	4½			2					x	irreg.blks.

Stratigraphic Description — NEW RINGGOLD SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
	23	362	C	cs-f	15			85	3									20% cov.
42	6½	368½	C	"	5			95	1½			1						
43	7½	376	DC	"	85			15	10			1				x	?	
	10	386	DG	"	35			65	2½			1	3					
45	3	389	DG	"	90			10	7			3						
	23½	412½	DG	"	35			65	3			2						argill.
	11½	424	DG	"	40			60	9			2					x	5' eroded
	6½	430½	DG	"	65			35	14			1						at base
	13½	444	DCG	"	30			70	4			2		s				monocline
50	7	451	DC	"	70			30	12			3	3					
	4	455	DC	"	5	80		15	2½	1½		2						
	12½	467½	DC	"	75	15		10	5½	2		2						
	18	485½	C	"	5	90		5	4	1½		2				x		
	14½	500	C	"	50	20		30	6½	1½		3				x		
55	3	503	C	cs		35		65		2		3						
	9	512	CD	cs-f	60	5		35	5½	1		2						culvert
	8	520	CD	"	10	50		40	3½	2		1		s				
	1½	521½	D	"	100				18									laminated
	6	527½	C	cs		20		80		1½		2		s				
60	32½	560	CD	cs-f	35	10		55	10	2		3				x		argill.
	9	569	C	"	75			25	8			3				x		
	10	579	C	"	95			5	9?			3	4					
	4	583	D	"	100				48?							x		laminated
	6	589	CD	"	65			35	5			3				x		
65	6½	595½	C	"	85			15	12			3					x	ang.blks.
	7	602½	DC	"	90			10	6			3	2	s	3			
	4	606½	DC	"	100				24									laminated
	7	613½	DC	"	50			50				2	4		3	x		
	10	623½	D	"	100				18?				3					
70	19½	643	CD	"	80			20	14			3				x	?	laminated
	5	648	CD	"	40			60	3½			3						
	7½	655½	CD	"	95			5	11			3	3					argill.
	10	665½	CD	"	85		tr.	15	4½			3			2	x		
	5½	671	CD	"	95			5	15			3				x		laminated
75	4	675	C					100				1						
	12	687	C	"	15	10		75	2	1½		2						
	7	694	C	cs		10		90		1½		2						sph. weath.
	31	725	C	"		85	5	10		2	½	2		s	1			traf. sign.
	9	734	C	cs-f	10	50	tr.	40	2½	1		3			3			argill.
80	15½	749½	C	"	5	50	15	30	2½	1½	1	3		s	3	x		
	4	753½	D	"	100				18									laminated
	6	759½	C	"	60		10	30	3½		1	2			3	x		argill.
	5	764½	CD	"	75			25	7			1						laminated
	5½	770	C	"	30	40	10	20	3½	1½	1	3			4	x		
85	3	773	C	cs		20		80		1		1						
	7½	780½	CD	cs-f	5	25	5	65	5	1½	3/4	3			4			

Stratigraphic Description — NEW RINGGOLD SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
	2	782½	C					100				1						
88	21	803½	CD	cs		15	20	65		2	1	3			2			
89	7	810½	CD	cs-f	30	60		10	10	3		2			4			laminated
90	11	821½	DC	"	90			10	14			3		s			x	eroded base
	13	834½	D	"	75	5	tr.	20	6	1½		3			4			laminated
	16½	851	CD	"	70	5		25	10	1		2	3			x		
	2½	853½	D	"	100				30									laminated
	8	861½	CD	"	20	10		70	5	2		3						argill.
95	3	864½	D	"	95			5	3			3						
	2	866½	C	"	30			70	2			3						argill.
	2½	869	D	"	100				30									laminated
	15½	884½	DC	"	85			15	5½			2	4					laminated
	4	888½	C	"	80			20	3			2						
100	35	923½	C	"	85			15	7			2	3	s		x		laminated
	6	929½	C	silty				100				3						
	6	935½	C	cs-f	85			15	10			2						lam.,argill
	6½	942	DCB	"	40		5	55	2½		1	3	3		2			
	13½	955½	CB	"	75		tr.	25	7			3	3	s				
105	3	958½	CB	silty				100				3						
	15	973½	CD	cs-f	35			65	5			3	1	s		x		plant frags
	6½	980	DC	"	95			5	10			3				x		laminated
	10½	990½	DC	"	30		tr.	70	3			3						argill.
	16½	1007	C	"	85			15	13			3		s				laminated
110	22½	1029½	C	"	20		5	75	7		1½	3	4	s				argill.
	5	1034½	C	"	95			5	5			3						laminated
	7	1041½	C	"	15			85	4			3						argill.
	5	1046½	CD	"	30			70	6			3						lam.,argill
	7½	1054	CD	"	40			60	3½			3						laminated
115	4	1058	C	"	95			5	4½			3		s				laminated
	6	1064	C	"	40			60	6			3	2	s	1			culvert
	3½	1067½	C	"	10			90	3½			3			3			
	6½	1074	CD	"	65		tr.	35	5			3	3		3			argill.
	16	1090	CDB	"	25			75	4½			3	4	s		x		argill.
120	6	1096	CB	"	5			95	5			3						argill.
	7	1103	CB	cs			5	95			1½	3		s	3			argill.
	7½	1110½	CBD	cs-f	5		tr.	95	3			2						sph.weath.
	1½	1112	D	"	90			10	9			3						
	3	1115	B					100				2						
125	5	1120	CB	cs-f	35		tr.	64	2			3		s				argill.
	5	1125	CB	"	90			10	2½			3		s				lam.,argill
	4	1129	CB	"	85			15	1½			3						laminated
	3½	1132½	B					100				3						sph.weath.
	8	1140½	B				5	95			½	3		s	4			argill.
130	7	1147½	B	cs-f	95			5	3			3	3					laminated
	10½	1158	CB	"	95			5	2½			3		s				laminated
	8	1166	C	"	95			5	4			3		s				laminated

Stratigraphic Description — NEW RINGGOLD SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
	14	1180	CBD	cs-f	95			5	2½			3		s	3			laminated
134	6	1186	CB	"	95			5	3½			3						argill.
135	11	1197	CB	"	95			5	4			3				x		laminated
	5½	1202½	C	"	100				66							x		laminated
	3	1205½	CB	"	85			15	3			2						laminated
	3	1208½	C	"	100				36									laminated
	4½	1213	CB	"	90			10	6			2		s				laminated
140	18½	1231½	CB	"	85			15	4½			1		s				laminated
	7	1238½	CB	"	35			65	4			1		s	3			laminated
	5½	1244	CB	"	10			90	2½			1			3			
	18	1262	CB	"	35			65	1½			1						
144	16	1278	BA	s	10			90	2½			1						Harrell 30% cov., end cut, 100' N. house

Section 5, Schuylkill Haven

Section 5 consists of Trimmers Rock exposed along the bluffs south of the Schuylkill River in the borough of Schuylkill Haven, Schuylkill County. The section begins at the base of red shales of the Catskill Formation exposed along the paved road leading south from Schuylkill Haven to Brommerstown on the Friedensburg 7½-minute quadrangle. The red shales dip north and occur at a point near the crest of the bluff 2800′ south of 40°37′30″ and 200′ east of 76°10′00″W.

Near the base of the bluff, but still above an area of relatively high ground, dark gray shales mark the base of the measured section at a point about 2000′ south of 40°37′30″N and 2200′ west of 76°10′00″W.

At the crest of the bluff, well above the lowest red bed, strata much like Trimmers Rock siltstone and shale comprise 10 feet of section in a road-cut, suggesting that here the only significant change between the Trimmers Rock and the Catskill is the occurrence of intermittent red shales.

Stratigraphic Description — SCHUYLKILL HAVEN SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load Struc.	Movement	Miscellaneous
			red	m	50			50										Catskill, at
																		P.P.#9-11-1,
																		road-cut at
																		curve to S.
1	95	95	G	f	50			50										70% covered
	67	162																covered
	4	166	DI					100				1						culvert
	8½	174½	DI	f-m	30			70	3½			1						65E. 35S. —
5	2	176½	D	f-c	100				24?									cgltic., wt.
																		qtz.
																		granules
6	12	188½																covered
	13	201½	DI	m	100			PTG	10			3						sl. cgltic.
	3	204½	I	f-m	95			5	5½			1		s				P.P. 6
	11	215½	DI	cs-f	15		5	80	3		½	1						
10	3½	219	DIG	"	95			5	4			3						
	24½	243½	DI	"	5		10	85	2½		3/4	1						
	1	244½	DI	"	100				12									
	3	247½	DI	"	35			65	3			1						
	6	253½	DI				10	90			3/4	1						
15	3½	257	DI	cs-f	20		5	75	2		3/4	1		s				
	7	264	DI	"	10		10	80	3½		1	1						
	8	272	DI	"	30		5	65	6		3/4	1						clay-rich
	7	279	DI					100				1						clay-rich
	4	283	DI	cs-f	65		5	30	7		1	1		s				clay-rich
20	6	289	DI					100				1						clay-rich
	2	291	DI	cs-f	70			30	2½			1						clay-rich
	7½	298½	DI	"	10			90	2			1		s				clay-rich
	4	302½	DI	"	90			10	21			1				x		laminated
	4	306½	DG	cs			5	95			3/4	1						
25	4	310½	DG	cs-f	20			80	2½			1		s				
	1	311½	D	"	100				4									
	6½	318	DI	"	10		5	85	3		3/4	1				x		
	8	326	DI	"	30			70	4			1		s				
	3½	329½	DI	"	10	30		60	2½	2		1						
30	4½	334	DG	"	25	20		55	3½	2		1						
	8	342	DIG	"	5	15	10	70	2½	1½	3/4	1						
	8	350	DI	"	30	10		70	4	1½		1		s				
	16	366	DG	"	25	5	15	55	2½	1	1	1						
	9½	375½	DI	"	80			20	11			2						P.P. 5
35	16	391½	DI	"	40			60	16			3						homocline
	6	397½	D	"	65			35	3			2						
	3	400½	D	"	100				?									
	6	406½	D	"	35			65	2½			2						culvert
	7	413½	D	"	25			75	2½			1						
40	5	418½	D	"	50			50	4½			2		s				

Stratigraphic Description — SCHUYLKILL HAVEN SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
41	8	426½	DG	cs-f	25		15	60	3		1	1						
42	3	429½	DG	"			10	90			3/4	2						
	4	433½	DI	"	65			35	7			2		s				
	6½	440	DI	"	35			65	3½			2	3					
45	3	443	DI	"	90			10	18			1						
	5	448	D	"	10		5	85	6		3/4	2						
	17½	465½	DI	"	25			75	2½			2						
	1	466½	D	"	100				13							x		
	8	474½	DG	"	15			85	3			3						
50	5	479½	DI	"	85			15	6			2	3			x		
	5	484½	DI	"	5	80		15	2½	2		3				x		
	11	495½	DI	"	80			20	11			1	2	s				
	7½	503	DI	"	10			90	4			2	3	s				on hillside
	8	511	D	"	100				?									P.P. 4
55	10	521	DI	"	70			30	5			2						
	2	523	DI	"	100				6?									
	9½	532½	DI	"	35			65	5½			2						clay-rich
	14	546½																covered
	10½	557	DI	cs-f	100											x		road-cut
60	4½	561½	DIG	"	40			60	5			1		s				
	21	582½	DC	"	5			95	2			1				x		
	4½	587	DC	cs		40		60		1		2				x		clay-rich
	11	598	DC	cs-f	5	10		85	4½	1½		1				x		
	11	607	DI	"	25			75	2½			1						clay-rich
65	2	609	DI	"	100				21?									
	7	616	DI	"	15	70		15	2	2		2		s	3			
	3½	619½	DI	"	20			80	3			1						argill.
	2½	622	DI	"	90			10	13			2		s				
	8	630	DI	"	35			65	3½			2						
70	6½	636½	DI	"	15			85	5			2						clay-rich
	9½	646	DI	"	80			20	9			2						clay-rich
	5½	651½	DI	"	70			30	12			1		s				
	47	698½	DI	"	20			80	2½			2	4					P.P. 3(top)
	8½	707	DI	"	35	15		50	4½	2		2		s				
75	7	714	DI	"	55			45	14			2						
	4	718	DI	"	10			90	1½			2						
	6	724	DI	"	30			70	3			2		s				culvert
	5½	729½	D	"	35			65	7			2		s				
	3½	733	DI	"	15			85	1½			2						
80	6	739	D	"	95			5	14		PTG							thins to E.
	2	741	DI	"	80			20	7			1						
	3	744	D	"	40			60	4½			1		s				
	6	750	D	"	65			35	4½			1						
	8	758	DI	"	95			5	22			1	4	s		x		
85	5½	763½	D	"	90			10	6			1		L				
	1½	765	D	"	20			80	2			2		s		x		

Stratigraphic Description — SCHUYLKILL HAVEN SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscelloneous
87	2½	767½	DI	cs-f	75			25	5⅓			1		s				
88	4½	772	DC	"	90			10	11			2		s				
	6	778	DCI	"	60			40	2⅓			2		s				P.P. 2
90	6½	784½	D	"	90			10	9			2		s				
	5½	790	DC	"	30			70	3			2	3					
	2½	792½	DI	"	100			PTG	10									
	3	795½	DI	"	85			15	3⅓			2						
	4	799½	DI	"	35			65	2			3						
95	3½	803	DI	"	95			5	7			3		s				
	3½	806½	DC	"	70			30	2			3						
	22	828½	D	"	90			10	18			2						
	5	833½	DC	"	45			55	6			2						
	3½	837	DC	"	85			15	7⅓			2						
00	12	849	DC	"	80			20	5⅓			2						argill.
	6½	855½	DI	"	30			70	7			2						argill.
	2½	858	DI	"	90			10	6⅓			2		s				
	14½	872½	DI	"	75			25	3⅓			2		s				
	6	878½	DC	"	25			75	3			2						
05	4½	883	DC	"	30			70	4			2		s				
	5	888	DC	"	65			35	8			1						
	6	894	DC	"	20			80	7			1						
	2⅓	896⅓	D	"	80			20	10			1		s				culvert
																		base of Trimmers Rock
	7	903⅓	DC	"	5			95	4			1						snowballs
10	2⅓	906	DC	"	20		10	70	5		3/4	1						high in cut
11	55	961	C					100				1	4					snowballs
12	3	964	DC	cs-f	30			70	2			1						clay-rich
	3	967	C					100				1						snowballs
	32	999	C					100				1						
15	2½	1001½	DCB	cs-f	30			70	4			1						
	7	1008½	CB					100				1						
	4	1012½	CB	cs-f	30			70	4			1						75E, 37S —
18	5	1017½	CB					100										50'E. of P.P. 21
																		covered

Section 6, Marysville

Portions of the lower Catskill, all of the Trimmers Rock, and a portion of the shale units below the Trimmers Rock dip south and are overturned in cuts along the Pennsylvania Railroad in the Borough of Marysville, Perry County. These exposures occur in the Harrisburg West 7½-minute quadrangle. Lower Catskill sandstones and red shales are exposed in a railroad tunnel south of Fishing Creek. There is a possibility that the upper part of the Trimmers Rock is cut out along the postulated westward extension of the Sweet Arrow Fault. The highest Trimmers Rock occurs about 25 feet south of the south end of the tunnel, 1500′ north of 40°20′00″N and 2800′ west of 76°55′ 00″W.

Thc base of the measured section, in dark-gray to black shales which weather buff, lies 500′ north of 40°20′00″N and 2100′ west of 76°55′00″W. A covered interval occupying several hundred feet of section lies next south, followed by well-exposed Montebello sandstones.

Stratigraphic Description — MARYSVILLE SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
	2		red	clay				100				1						35'S of N.
																		end tunnel
1	8	8	I					100				1						E.side R.R.
	4½	12½	JD	cs-f	35			65	3			1	3					75E,72S O.T.
	2	14½	D					100				1						
	4	18½	JD	"	50			50	4½			1						
5	6	24½		"														covered
	8½	33	JH	"				100				1						
	2½	35½	G	"				100				1						
	14	49½	DJ	"	20			80	6			1	4					
	12	61½	J	"	80			20	9			1		s		x		
10	10	71½	I	"				100				2						
	1½	73	J	"	100				18									
	10	83	I	"	25			75	1½			2						
	4	87	G	"	15			85	3½			1	3					
	3	90	I	"				100				1						
15	2	92	I	"	90			10	7			1						
	6½	98½	IG	"	30			70	4			1						
	7	105½	I	"	10		10	80	4		½	1						
	12	117½	IG	"			10	90			½	1						
	7	124½	GI	"	45			55	3			1	3					
20	3	127½	D	"				100				1						
	13½	141	G	"	50			50	3			1						80% cov.
	4½	145½	G	"				100				1						
	7	152½		"														covered
	18	170½	GI	"	15			85	2½			1						
25	3	173½	GI	"	30		5	65	1½		½	1						
	14	187½	GI	"	15			85	1½			1						
	7½	195	GI	"	30			70	5			1						
	8	203	G	"	10		5	85	2½		½	1		s				
	5	208	I	"				100				1						
30	7	215	D	"				100				1						snowballs
	6½	221½	D	"				100				1						
	2½	224	DG	"	40			60	4			1						
	3	227	DG	"	5			95	2			1						
	1	228	DG	"	70			30	5½			1	4					
35	3	231	DG	"	10			90	2			1						
	2½	233½	DG	"	15			85	1½			1						
	2	235½	DG	"	40			60	2½			1						
	7	242½	DG	"	15		5	80	2		½	1	4			x		
	8	250½	DG	"	55			45	14			1		s		x		
40	9	259½	HG	"	5			95	1			1						
	1	260½	D	"	100				4				2					
	3½	264	G	"	5			95	1			1						
	1½	265½	J	"	100				18?							x		
44	2½	268	G	"	15			85	3			1						

Stratigraphic Description — MARYSVILLE SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
45	1½	269½	DG	cs-f	70			30	5			1	4			x		
	2½	272	G	"				100				1						
	3	275	DG	"	30			70	4			1		s				
	6	281	DG	"	5			95	2			1		s				
	3	284	DG	"	60			40	5½			1		s		x		
50	4	288	DG	"	5			95	1½			1						
	1½	289½	J	"	100				17½							x		
	3	292½	DG	"	30			70	3			1						
	4	296½	G	"	30			70	8?			1		s		x		
	5	301½	DG	"				100				1						
55	1½	303	D	"	100				16									
	5	308	D	"				100				1						
	3	311	DG	"	80			20	18			1		s		x	x	OT pillow
	5	316	DG	"	65			35	6			1						
	3	319	D	"	35			65	3			1						
60	7	326	DG	"	20			80	2½			1	4			x		
	5½	331½	DG	"	60			40	5			1		s		x		
	5	336½	GI	"	15			85	3			1				x		
	2	338½	GI	"	60			40	4			1						
	6½	345	GI	"	10			90	3			1						clay-rich
65	3	348	I	"	70			30	10			1				x		
	4½	352½	GI	"	5			95	3½			1						
	6½	359	DG	"	30			70	5½			1				x		
	1	360	I	"	100				12									
	5	365	GI	"	30			70	3½			1	4					
70	1	366	D	"	100				14									
	6	372	GI	"	40			60	6			1						
	2	374	I	"	90			10	10			1						
	2	376	G	"				100				1						
	2⅓	378⅓	GI	"	80			20	11			1				x		
75	6	384⅓	GI	"	25			75	3½			1						
	4⅓	389	GI	"	50			50	7			1		s				
	5	394	GI	"	20			80	2⅓			1						
	3⅓	397⅓	GI	"	60			40	6⅓			1		s		x		clay-rich
	5	402⅓	GI	silty				100				1						fossils
80	4	406⅓	GI	cs-f	65			35	11			1				x		
	2	408⅓	G					100				1						
	6	414⅓	GI	"	75			25	4			1	2			x		
	2	416⅓	G					100				1						
	4	420⅓	GI	"	40			60	5½			1						
85	2	422⅓	G					100				1						
	4	426⅓	GD	"	50			50	7			1				x		
	2⅓	429	I	"	100				30?					s				
	5⅓	434⅓	GI	"	15			85	3⅓			1						
	4	438⅓	DI	"	35			65	4⅓			1		s				plant frags
90	11⅓	450	GDI	"	30			70	4⅓			1						

Stratigraphic Description — MARYSVILLE SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscelloneous
					I	II	III	Sh	I	II	III							
91	3	453	I	cs-f	90			10	15			1		s		x		
	3½	456½	GI	"	20			80	4			1						clay-rich
	8	464½	DI	"	50			50	9			1	2	s		x		
	4	468½	GI	"	90			10	10			1		s		x		
95	1½	470	GI	"	10			90	1½			1		s				
	9	479	GI	"	70			30	6½			1	2					
	1½	480½	I	"	100				19									
	4	484½	GI	"	15			85	2			1	2					
	4	488½	GI	"	45			55	4½			1	2			x		
00	1½	490	I	"	100				18					s				
	5½	495½	GI	"	30			70	3½			1				x		
	4½	500	GI	"	65			35	3			1		s				
	17	517	GI	"	25			75	3½			1						clay-rich
	7½	524½	ID	"	30			70	2½			1	4					
05	10	534½	ID	"	20			80	2½			1		s				
	4½	539	ID	"	60			40	4			1	2	s				
	4	543	DI	"	25		5	70	2½		3/4	1						
	5	548	DI	"	30			70	4			1	3	s				
	5	553	DI	"	25			75	4			1		s				
10	6	559	DI	"	35		5	60	3½		3/4	1						
	1	560	D	"	100				10									
	14½	574½	DI	"	50			50	5			1		s				
	10	584½	DI	"	35			65	4			1	3	s				
	19	603½	DI	"	25			75	5			1		s		x		
15	10½	614	DI	"	40			60	6			1	4	s				
	4	618	DI	"	10			90	3			1		s		x		sh. weath.
	4	622	DIG	"	60		5	35	5½		3/4	1		s				white
	21	643	DI	"	20			80	2½			1		s				
	3	646	DI	"	90			10	5			1		s				
20	4½	650½	DI	"	40			60	3½			1		s				clay-rich
	5	655½	DI	"	15			85	2½			1		s				
	2	657½	DI	"	95			5	6½			1						W.side R.R.
	16½	674	DI	"	15			85	4½			1		s				
	8	682	DI	"	5			95	2			1						
25	12	694	DI	"	25			75	5			1						
	9	703	D	"	10			90	4½			1						
	7	710	D	"	15			85	1½			1						
	1	711	D	"	100				12									
	15	726	DG	"	5			95	1			1						
30	12	738	DG	"	5			95	2			1						
	30	768	DG	"	15			85	2½			1						E.side R.R.
	34	802	C	"				100				1						
	34½	836½	C	"				100				1						
	11	847½	C	cs			5	95			3/4	2						clay-rich
35	17	864½	C	cs			5	95			3/4	3						
36	42	906½	CB	cs	10			90	2			2						Harrel

Section 7, Dromgold

The Trimmers Rock is intermittently exposed in road-cuts and hillside exposures south of the village of Dromgold, Perry County, on the Shermans Dale 7½-minute quadrangle. The lowest red shales of the Catskill Formation crop out along Routes 34 and 850 at a point about 2500′ north of 40°20′00″N and 5200′ west of 77°10′00″W.

The upper half of the section is poorly exposed in the road-cuts, but considerable strata are exposed on the hillsides above. The lower one third is very well exposed in a series of barrow pits immediately southeast of the intersection at Dromgold. In the road-cuts at the intersection, the base of the measured section lies at a point about 4650′ north of 40°20′00″N and 7000′ west of 77°10′00″W. The next-lower exposure consists of clay-rich shale and minor siltstone of the Frame Member of the Mahantango Formation behind a garage about 800′ north on the Camp Carson Long road.

Although 717′ of the total 1565½′ of section at Dromgold is concealed, the section is considered significant enough to be measured because it lies in an area of marked thinning of the entire Upper Devonian section.

Stratigraphic Description — DROMGOLD SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
																		Catskill
																		road-cut
																		50E. 26S.←
	6		red					100				3						clay-rich
1	50	50																cov., valley
	26	76	IG	cs-f	5			95	1			1						65E. 23S.←
	1½	77½	I	"	100				4									fossils
	3½	81	J	"	30			70	1			1						
5	1½	82½	HI	"	100				3									
	4	86½	J	"	5			95	1			1						
	5	91½	IG	"	5		tr.	95	1			1						
	3½	95	G	"	25			75	1			1						
	3	98	G					100				1						
10	1	99	I	cs-f	80			20	3			1		s				
	4	103	J	"	10			90	1			1	3	s				
	1	104	I	"	100				12									
	7½	111½	I	"	20			80	1			1						small tec.
	10	121½	G	"	5		tr.	95	1			1						folds
15	15½	137	G	"	5		tr.	95	1			3						
	4½	141½	J	"				100				1						65E. 30S.←
	87	228½		"														cov., valley
	2½	231	I	"				100				1						65E. 35S.→
	3	234	J	"				100				3						
20	2	236	I	cs-f	10			90	1½			3						
	1	237	IK					100				1						clay-rich
	12	249	J	cs-f	10			90	1½			2						irreg. fiss.
	5½	254½	J					100				1						snowballs
	2½	257	J	cs-f	25		tr.	75	1			1						
25	½	257½	I	"	100				4				1					
	3	260½	I	"	35			65	1			1						
	5½	266	J					100				1						irreg. fiss.
	8½	274½	I	cs-f	35			65	1½			1						
	6	280½	J	"			10	90			1	1						
30	3	283½	J	cs		tr.		100				2						
	5	288½	IJ					100				1						
	12½	301	IG					100				3						65E. 26S.←
	208	509																cov., valley
	6	515	I	cs-f	60			40	1½			3						55E. 35S.←
35	13½	528½	J	"	90			10	5			3	4					
	2½	531	J					100				3						clay-rich
	1½	532½	J				tr.	100				3				x		
	10	542½	C	cs-f	70			30	7			1			4			
	8	550½	C	"	50		tr.	50	1½			3						10% covered
40	12	562½	C	"	70			30	3			3	2					
	5½	568	C	cs			10	90			1							irreg. fiss.
42	2	570	C	cs-f	100				24				1					

Stratigraphic Description — DROMGOLD SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneou
43	6	576	C					100				1						irreg.fiss
	3½	579½	C	cs-f	100				40?							x		
45	14	593½																covered
	1	594½	C	silty				100				3						irreg.fiss
	3½	598	J	cs-f	100				40?							x		
	4	602	C	silty				100				3						irreg.fiss
	1	603	J	cs-f	100				12							x		
50	5	608	HI	silty				100				3				x		
	1½	609½	HI	cs-f	100				18							x		
	3½	613	HI	"	80			20								x	x	mixed
																		pillows
	2	615	I	silty				100				3						55E. 38S.–
	164	779																covered
55	3	782	IJ	silty				100				3				x		on hillsid
	2	784	I	cs-f	80			20	9			3				x		
	2	786	I	"	100				24				4	s				
	3	789	I	"	70			30	6			3				x		silty sh.
	2	791	I	"	100				24									irreg. bdg
60	2	793	I	"	70			30	4			3				x		
	1	794	I	silty				100				3						
	84	878																covered
	5	883	I	cs-f	50			50	3			3						silty sh.
	7	890	I	silty				100				3						irreg.fiss.
65	3	893	I	cs-f	80			20	6			3				x	x	eroded bas
	1	894	I	silty				100				3						
	3	897	I	cs-f	35			65	2			3						silty sh.
	15	912																covered
	2	914	I	cs			10	90			3/4	3						silty sh.
70	9	923	I	cs-f	60			40	2½			3						silty sh.
	4	927	I	silty				100				3						
	1	928	I	cs-f	80			20	4			3				x		
	6½	934½	I	"	80			20	3			3				x	x	eroded base
	5	939½	I					100				3						40% cov.
75	14½	954	IH	cs-f	25			75	2			3						silty sh.
	2	956	IH	cs			10	90			3/4	3						silty sh.
	5	961	C					100				3						20% covered
	2½	963½	C	cs-f	30			70	2			3						silty sh.
	6	969½	C	"	10			90	2			3						laminated
80	5	974½	C	"	65	20		15	6	1½		1		s				in road-cut
	12½	987	C	"	40	50		10	3	1½		3		s				
	7	994	D	"	25	55		20	2	1		1						
	1	995	C	"	100				12									
	2½	997½	B					100				3						
85	11	1008½	I	cs-f	80			20	10			3	4	s				
	6½	1015	CD	"	35			65	3			3	4					
	4	1019	C	"	90			10	4			1						

Stratigraphic Description — DROMGOLD SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
	5	1024	C	cs-f	70			30	2½			3		s				
39	3½	1027½	C	"	10		tr.	90	1			1	4					
90	2½	1030	C	"	40			60	2			3	2					laminated
	3	1033	C	"	90			10	5			3						silicious
	4½	1037½	C	"	10			90	2			1						
	5	1042½	I	"	95			5	5			3						yel. stain
	7	1049½	D	"	50			50	7			1						
95	½	1050	D	"	100				10									silicious
	7½	1057½	D	"	15			85	2			1						
	1	1058½	D	"	100													silicious
	18	1076½																covered
	11	1087½	C	cs-f	20			80	3			1	4					
00	10	1097½	C	"	5		tr.	95	1½			3						
	7	1104½																covered
	28½	1133	B	cs			5	95			3/4	1						quarry
	8	1141	BK					100				1						sph. weath.
	12½	1153½	BK	cs			5	95			3/4	1						60E. 33S.
05	37	1190½																cov., valley
	13½	1204	I					100				1						rear house
	29	1233	BA	cs			5	95			1	1						
	10	1243	BA					100				1						sph. weath.
	6½	1249½	BAK	cs			15	85			3/4	1						
10	8	1257½	BK	cs-f	10			90	1½			1						
	1	1258½	CK	"	100				12									silicious
	11	1269½	BA					100				1						sph. weath.
	10	1279½	BF					100				1						
	9	1288½	BF	cs	30			70	2			1						
15	3½	1292	B					100				1						
	18	1310	BF	cs	30			70	1½			1						
	4	1314	A					100				1						
	14	1328	BFK					100				1						road-cut
	12	1340																covered
20	2½	1342½	I	cs-f	100				30?									silicious
	3	1345½	C					100				1						sheared
	5	1350½	I	cs-f	85			15	8			1		s				
	5	1355½	DG	"	15			85	1½			1						
	3½	1359	DIG	"	90			10	9			1		s				
25	2½	1361½	BF	"	20			80	1			1						
	4	1365½	DF	"	65			35	7			1		s				
	3	1368½	BF	"	5			95	1			1						
	2	1370½	A					100				1						
	13	1383½	BF	cs-f	35			65	2			1		s				
30	2	1385½	A					100				1						
	15	1400½	BF	cs-f	15			85	1			1						
32	26	1426½	BF	"	5			95	1			1						
																		cov. on curve

Section 8, Girtys Notch

Section 8 was studied where the Trimmers Rock is exposed in cuts along Routes 11 and 15, 2 miles north of the village of New Buffalo, Watts Township, Perry County. The exposures described occur in the Halifax 7½-minute quadrangle, near the spot where the highway passes through a cut at Girtys Notch in the eastern end of Half Falls Mountain. The Notch has historical meaning and is well known locally.

A nearly complete section is revealed in high road-cuts at this locality, the lowest red shales of the Catskill Formation dipping south at a point about 8100′ south of 40°30′00″N and 2400′ east of 76°57′30″W. In the lower portions of the section, the dark shales are locally contorted in at least two open folds, and therefore not much reliability can be given to estimated thicknesses of basal units. The measurements were carried through to a poor exposure of fossiliferous limy shale in the stream gorge immediately south of the Notch. This questionable Tully Limestone lies at a point about 4350′ south of 40°30′00″N and 1500′ east of 76°57′30″W.

Stratigraphic Description — GIRTY'S NOTCH SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
	4		red				tr.	100				1			2			Catskill
1	3	3	FC				tr.	100				1			2			red stain
	8	11	FC				tr.	100				1						40E. 33S.
	6½	17½	FC	vf	100				40?						2			graded bdg.
	1½	19	FC	sandy				100				3			4			
5	5	24	JF				tr.		60?									red stain
	1½	25½	G	cs		100				3/4								graded bdg.
	2½	28	J	vf	100				30?						4			
	3	31	G	"	95			5	8			1						
	3	34	JF	"	100				36?							x		
10	3	37	F	"	100				36?				4					laminated
	5½	42½	F	"	100				3									laminated
	11	53½	G	"	90			10	8			1						char. frags.
	4	57½	J	cs		100				3								
	6	63½	JC	cs-f	35			65	7			1	2	s				silicious
15	7½	71	C				tr.	100				2		s				graded bdg.
	4	75	C	cs		100				3								red stain
	4	79	J	cs-f	10			90	1½			1						
18	6½	85½	C	"	10			90	1			1						cgltic., wh. quartz ½" max.
19	5	90½	JC	cs-f	90			10	5			1						cgltic., wh. quartz ½" max.
20	4½	95	C	c			tr.	100				1						
	1	96	J	cs-f	100				12									silicious
	11	107	JH	cs		5		95		3/4		1			3			
	14½	121½	JH	cs		10		90		3/4		1						P.P. 417
	3	124½	J	cs-f	90			10	1½			1						
25	3	127½	J	cs-f	10			90	1			1						irreg. bdg.
	11	138½	J	"	5			95	1			1						argill.
	10	148½	C	silty				100				1						
	2	150½	C	cs		100				4								graded bdg.
	3	153½	HD					100				1						
30	2	155½	C	cs-f	85			15	5			1						
	56	211½	C					100				1						
32	2½	214	C	cs-f	70			30	5			1						intersect. 2 cut ramps
33	12	226	J	cs-f	15			85	2			1						on N. ramp
	2½	228½	C	"	50			50	3			1						
35	2½	231	J	"	60			40	3			3				x		pseudo-fiss.
	2½	233½	CF	"				100				2						
	10	243½	CF					100				1						red stain
	4	247½	D	cs-f	90			10	4			1	4					
	2	249½	C	"	95			5	6							x		irreg. bdg.
40	2½	252	C	"	95			5	9			3						

Stratigraphic Description					GIRTY'S NOTCH SECTION													
					% Lithology				Average Bedding Thickness									
Unit No.	Thickness	Totol Thickness	Color	Grain Size	I	II	III	Sh	I	II	III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscelloneous
	3½	255½	J	cs-f	80			20	4			3						
42	4	259½	J	"	95			5	8			3						
43	4	263½	J	"	85			15	3			3				x	?	
	8	271½	J	"	30			70	1½			3						
45	6½	278	J					100				3						green stair
	1	279	G					100				3						
	3	282	J					100				3						
	8	290	J	cs-f	30			70	3			2	2	s				
	3	293	G	"	10			90	2			1						
50	15	308	J	"	5			95	1			1						
	36½	344½	G					100				1		s				small fault
	4	348½	G	cs-f	70			30								x		
	4½	353	G	cs		80		20		1		1						
	3½	356½	J	cs		100				2								
55	7½	364	GJ	cs-f	35			65	5			1						
	12	376	GJ	"	5			95	6			1				x		sl.diastem
	3½	379½	J	"	85			15	6			1			4			
	4½	384	GJ	"	50			50	2			3	2					
	3½	387½	J	"	65			35	5			3				x		irreg. bdg.
60	3	390½	J	"	100				36?									
	12	402½	J	"	20	15		65	5	2½		3						
	5	407½	J	cs		70		30		4		3						laminated
	8	415½	GJ	"		15		85		2		2						micaceous
	5½	421	J	cs-f	15			85	3			2	1					
65	3	424	J					100				3						
	4	428	C	cs-f	5			95	1			3						
	2	430	J	"	20			80	3			1						
	2½	432½	JC	cs		25		75		3/4		1						irreg. bdg.
	31	463½	J					100										end ramp
70	6	469½	C	cs-f	50			50	2			1	1	s				
	12½	482	CJ	"	20	15		65	1½	2		3	4					P.P. 619
	20	502	C					100				1						micaceous
	6	508	C	cs-f	10	10		80	1½	1		3	2					
	16	524	C					100				1						
75	2	526	C	cs-f	40			60	2			3	2					80E. 44S.—
	32	558	CK	"	5			95	1½			1						
	48	606																covered
	18½	624½	CI					100				1						65E. 40S.—
	16	640½																covered
80	5	645½	C	cs-f	10			90	1			1	3					on hillside
	41	686½	C	clay				100				1						P.P. 620
	7½	694	CD	cs-f	10			90	1			1						
	30	724	DG					100				1						cor. house
	6½	730½	CG	cs-f	60			40	8			3	3					
85	5	735½	J					100				3						
	3½	739		cs-f	80			20	7			1				x	?	

Stratigraphic Description — GIRTY'S NOTCH SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscelloneous
	6	745	DI	cs-f	80			20	7			1						red stain
88	18	763	CI					100				1						rear house
89	123	886																covered
																		st. valley
90	28	914	C	cs-f	20			80	1			2						80E. 54S.
	6	920	J					100	3									
	2	922	J	cs-f	95			5	3			3				x	x	O.T.Pillow
	2½	924½	J	"	95			5	4			3						yel. stain
	10	934½	JC	"	50			50	10			2						
95	6	940½	J					100				2						
	6	946½	J	cs-f	60			40	2½			3						
	3	949½	CJ	"	80			20	4			3		s				
	13	962½	G	"	25			75	2			1	4					silty sh.
	2½	965	G	"	80			20	6			1	3					
100	3	968	GJ	"	10			90	1½			1		s				silty sh.
	6½	974½	GJ	"	60			40	3			1	4					
	4	978½	GC	"	15			85	2			1						silty sh.
	3	981½	GC	"	85			15	3			1						argill.
	1	982½	C					100				1						
105	14	996½	CJ	cs-f	5			95	1			2						graded bdg.
	3	999½	CJ				tr.	100				1			3			graded bdg.
	3	1002½	CJ	cs-f	5			95	1			1		s				silty sh.
	11	1013½	CJ				tr.	100				1			2			
	5	1018½	CJ	cs-f	5			95	1			1			3			
110	31	1049½	CJ				tr.	100				1			4			silty sh.
	9	1058½	CJ	cs-f	20			80	1½			1						
	7½	1066	JC	"	80			20	7			1						
	9	1075	J	"	35			65	4			3						argill.
	12	1087	CJ	"	20		5	75	3		1		1	s				argill.
115	8	1095	JC	"	70			30	10			1	1					argill.
	6½	1101½	C	"	5			95	1			3						silty sh.
	2	1103½	JC	"	75			25	6			1	1					
	6	1109½	J				tr.	100				2			4			
	7½	1117	C	cs-f	10			90	2½			3	3					
120	2	1119	JC	"	80			20	8			3	1		4			
	1½	1120½	CJ	"	25			75	3			3	1					argill.
	17½	1138	CJ	cs	85			15	4			3			4			irreg. bdg.
	7	1145	C	cs-f	80			20	3			3						
	8	1153	C	"	40			60	2½			1						monocline
125	5	1158																cov., swale
	9	1167	C	cs-f	65			35	7			1						foss. in sh.
	7½	1174½	C	"	60			40	3			1						
	5	1179½	C					100				2						
	9	1188½	CJ	cs-f	45			55	6			2	1					
130	5½	1194	C	"	5		tr.	95	1			3						
	4	1198	J	"	60			40	7			3						red stain

Stratigraphic Description — GIRTY'S NOTCH SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
	17	1215	JC	cs-f	10	80		10	7	3½								argill.
133	5	1220	CJ	"	25	20		55	2	1½		3	2					red stain
134	5½	1225½	JC	"	55	25		20	7	1½		3						
135	14	1239½	JC	"	15	50		35	3	1½		1	3		3			
	4	1243½	CJ	"	25	65		10	4	5		3	4					
	4½	1248	C	silty				100										
	8	1256	CJ	cs-f	30			70	3			1	3					silty sh.
	13	1269	CJ	"	75			25	8			2	1					
140	18½	1287½	C	"	45	40		15	3	2		3	2					
	7½	1295	C	silty				100				3						
	6	1301	C		60	30		10	5	2½		3	2					
	3	1304	C	clay				100				2						
	2	1306	C	cs-f	80			20	6			1	4					
145	4½	1310½	C	"	60	20		20	1½	1		3	4					graded bdg.
	5½	1316	C	"	15	85			3	2½			2					graded bdg.
	4	1320	C	"	5	95			1½	2			3					laminated
	3½	1323½	C	"	70	20		10	5	1½		1						laminated
	3	1326½	C	"	45	30		25	5	2		1						
150	4½	1331	C	"	30	30		40	3	2		1			4			
	3	1334	C	"	80	10		10	6	1		3			4			
	3	1337	C	"	25	20		55	5	1		1	4					
	10½	1347½	C	"	15	55		30	3	2½		3						
	6	1353½	C	cs		90		10		5		3						diastem
155	6	1359½	C	cs-f	60			40	4								x	ang. blocks
	2½	1362	C	cs		90		10		5		3						
	5	1367	CJ	cs-f	75	15		10	9	1		3						
	3	1370	C					100										
	2	1372	C	cs-f	60			40	4			3					x	eroded base
160	3	1375	C	"	95			5	12			3	2					sh. ptgs.
	6½	1381½	C	"	5	95	tr.		1	4								
	1	1382½	CJ	"	70			30	3			3				x		
	4	1386½	C	"	10	45		45	1½	2		3						
	1½	1388	C	"	100				5									laminated
165	3	1391	C	"	20			80	7			3			2	x		
	14	1405	C	"	30	25		45	5	2		1						
	10	1415	C	"	10	90			9	2			3					
	4	1419	C	cs		30		70		3		1						
	4½	1423½	C	"	25			75	8			1						
170	4½	1428	C	"	40			60	4							x		str. valley
	7½	1435½	C					100				1						
	5	1440½	C	cs-f	15	25		60	2	2		1				x		
	4	1444½	C	"	90	5		5	6	2½		3						
	11½	1456	C	"	30	10		60	4	1½		3	2		3			
175	5	1461	C	"	60	10		30	9	1½		3		s		x		
	5	1466	C	"		100	tr.			2								
	17	1485	C	"	40			60	6			3	3	s	2			

Stratigraphic Description — GIRTY'S NOTCH SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
	9	1492	C	cs-f	70	15		15	9	2		3	3		3			
179	13	1505	C	"	25	15		60	4	2½		3	4		2			
180	2⅓	1507½	C	cs-f	90			10	11			3						laminated
	17	1524½	C	"	35			65	5			3	2		2			graded bdg.
	17⅓	1542	C	"	75	15		10	4⅓	3		3			2			graded bdg.
	4	1546	C	"	5	60	tr.	35	3	6		3	4					
	11½	1557½	CI	"	80	5		15	8	1½		3	4					
185	8	1565½	C	"	20	60		20	7	7		3						
	2	1567½	C	"	60			40								x		
	5	1572½	CJ	"	10	55		35	2½	4		3			3			red stain
	26	1598½	C	"	5	80	tr.	15	2	6		3	4					
	7⅓	1606	CD	"	15	55		30	2	3⅓		3	2					small fault
190	12⅓	1618⅓	DC	"	90			10	5			3						
	8	1626⅓	DC	"	20	5		75	4	5		3						
	8	1634⅓	DC	"	90			10	5			3						
	9	1643⅓	DC	"	85			15	4			3						
	5	1648⅓	DC	"	95			5	10			3						sh. ptgs.
195	7⅓	1656	C					100				3						
	13	1669	C	cs-f	10			90	2			3						clay sh.
	19	1688	C	"	20			70	1½			3						silty sh.
	3⅓	1691½	C					100				3						silty sh.
	19⅓	1711	C	cs-f	30			70	4			1						
200	20	1731	C	"	30			70	2½			1						
	3	1734	C					100				2						
	6	1740	C	cs	65			35	7			3						
	12⅓	1752⅓	C	cs-f	5			95	1			1						silty sh.
	12	1764⅓	CF	"	15			85	1½			1						silty sh.
205	20	1784⅓	C	cs	5			95	1			1						end lg.cut
	14	1798⅓	C					100				2						silty
	2	1800⅓	C	cs	75			25	3			1						argill.
	6	1806⅓	C	silty				100				2						argill.
	3	1809⅓	C	cs	40			60	2			2						
210	6	1815½	C	cs-f	5			95	1			1						
	8	1823½	C	"	50			50	3			1						tec. folds
	5	1828½	C					100				1						
	15	1843½	C					100										silty
	90	1933½	C	cs-f	10			90	2			1						contorted
215	23	1956	C	"	5			95	1			3						argill.
	48	2004	C	"	5			95	1			1						argill.
	75	2079	CB	"	10			90	1			2						argill.
	293	2372		silty				100										Harrell.
																		clc. sh.
																		Tully (?)
																		at base
																		75E. 42S. →

Section 9, Juniata River

Section 9 was studied in road-cuts along Routes 22 and 322 in Howe Township, Perry County. The section begins at the base of south-dipping red Catskill shales about 3 miles airline east of Newport, on the Duncannon 7½-minute quadrangle. This point lies about 4700′ south of 40°30′00″N and 1800′ east of 77°05′00″W on a farm road above the highway. Most of the section was measured in road-cuts along the highway.

The base of the measured section lies at the base of 41 feet of shale at a point about 7050′ south of 40°30′00″N and 2800′ east of 77°05′00″W along the highway. Stratigraphically below this, there is a covered interval of about 100 feet, followed by about 39 feet of Trimmers Rock dipping steeply north and faulted at the base. It is thus not possible to obtain a complete section at this locality.

Section 9 was named "Juniata River" because it is in closest proximity to that feature.

Stratigraphic Description — JUNIATA RIVER SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
	24		red	cs-f	55	10		35	10	5		1						Catskill, on unpaved road above highway
1	24	24	G	cs		15		85		1½		1			2			E-W, 57 N.
	12½	36½	GC	cs-f	65			35	7			1						
	9	45½	GJ					100				1						
	4	49½	G	cs-f	35			65	4			1			1			
5	17	66½	GJ	"	5			95	2			1						
	20	86½	G					100				1						
	7	93½	G	cs-f	35		tr.	65	2			1			4			
	20	113½	G	"	10			90	3			1						50% covered
	25	138½	G	"	90			10	4			1						bend in road
10	15	153½																covered
11	12	165½	GI	cs-f			50	50			3/4	1						on hillside below road
12	12	177½	CI					100				1						
	18	195½	CI	cs-f	10			90	3			1						50% covered
	10½	206	CI	"	60			40	4			1		s				
15	14	220	GI					100				1						
16	8½	228½	GI	cs-f	30			70	2			1						end outcrop on road
17	82	310½																covered
18	5	315½	CJ	cs-f	30			70	3			2						on highway at culvert
19	6½	322	CJ	cs-f	75			25	3½			1	4					E-W, 57N.
20	2½	324½	CJ	"	60		tr.	40	1½			2						
	2½	327	CJ	"	90			10	5			2			4			
	3	330	CJ	"	80			20	2½			2		s				
	2	332	CJ	"	100				12							x		
	2½	334½	CJ					100				2						
25	1½	336	CJ	cs-f	100				17?									
	2½	338½	CJ	"	90			10	4			1	4					
	1	339½	CJ	"	100				14?							x		
	4½	344	CJ	"	75			25	3½			1		s	4			
	2	346	CJ	"	100				12							x		
30	4	350	CJ	"	90			10	3			1	3					
	6	356	CJ	"	40		20	40	2		½	2			3			
	4	360	CJ	"	90			10	6			1						argill.
	8½	368½	J	"	50		20	30	3		3/4	1	3		3			
	8	376½	C	"	10		30	60	1½		3/4		4					
35	3	379½	C	"	85			15	7			1						
	3½	383	C	"	25			75	2			1						
	5½	388½	C					100				1						
38	12	400½	C															covered pwr.pole 50

Stratigraphic Description					JUNIATA RIVER SECTION													
Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
39	10	410½	CJ					100				1						on hillside
40	3½	414	J	cs-f	50			50	5			1						
	8	422	CJ					100				1	1					in road-cut
	4	426	CJ	cs-f	90			10	3½			1	2					
	9	435	CJ	"	30			70	4			2	4		3			
	3	438	GJ	"	60			40	5			1	4		3			
45	3	441	GJ	"	95			5	7			2	4					
	6½	447½	GJ	"	5	75		20	3½	2		1	3					
	3½	451	GI	"	70	15		15	4	1½		1	3					
	4	455	G	cs		40		60		1		2	3		2			
	4	459	G	cs-f			40	60			3/4	1			2			
50	5	464	G	"	20		20	60	2½		½	1						
	5	469	C	"	10		50	40	1½		3/4	1						
	7	476	C	"			20	80			½	3						on hillside
	13½	489½	C	"	20		30	50	2		3/4	1						
	5	494½	C	"	30		10	60	2		3/4	1						
55	42	536½																covered
	3½	540	CJ	cs-f	25			75	3			1						in road-cut
	46½	586½																covered
	9	595½	C	cs-f	20			80	1½			1						
	40	635½																covered
60	7	642½	C	cs-f	20			80	2½			1						on hillside
																		opp. pwr.
																		pole 51
61	2	644½	CJ	cs-f	40			60	3			1						in road-cut
	10	654½	CJ	"	95			5	9			1		s				
	2	656½	CJ	"	75			25	3			1						
	8	664½	GJ	"	95			5	12			1		s				
65	2½	667	GJ	"	70			30	3			1						
	4	671	J	"	95			5	10			1	2	s				
	6½	677½	C	"	60		20	20	1½		½	1			3			
	7	684½	C	"	50		20	30	4		½	1	1					
	2½	687	C	"	60			40	4			1	2					
70	1½	688½	C	"	60			40	5			2		s		x	x	O.T. sole
	6	694½	J	"	80			20	3			1						
	6½	701	J	"	35			65	2½			1	1		2			
	4	705	GC	"			30	70			½	1		s	3			
	7	712	GC	"	15		30	55	4		3/4	1						
75	2½	714½	G	f	90			10	6			1	2					
	4½	719	C					100				1						
	1½	720½	J	cs-f	100							7				x		
	5½	726	J	f	10		20	70	1½		½	1						
	5½	731½	GJ	cs-f			10	90			1	2						isol. foss.
80	7½	739	CJ	"	25		tr.	75	3			1	3		3			
	3	742	J					100				1						
82	6	748	J	cs-f	10	60		30	2½	1		1	4	s				

Stratigraphic Description — JUNIATA RIVER SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscelloneous
83	3	751	CJ	cs-f	60	20		20	3½	1½		3						
	5½	756½	C	"	20	15		65	2	1		2	2					
85	2	758½	C	"	70			30	3½			3	1		2	x		
	1½	760	G	cs		80		20		1½		3						
	5	765	J	cs-f	40	10		50				3				x	x	eroded base
	4	769	J	cs		80		20		½		3		s				
	6½	775½	J	cs-f	40	20		40	4½	½		3		s	4	x	x	cast on
																		cast
90	3	778½	J	"	10	80		10	2½	½		3				x	x	eroded base
	3½	782	J	"	90		tr.	10	2½			3						
	2	784	J	cs		70		30		1½		3		s				
	2	786	J	cs-f	95			5	4½			3		s				
	7½	793½	J	"	25	50		25	3½	1		3		s				
95	6	799½	J		50	10		40	4		3/4	3	2	s				
	2½	802	CF	"	80			20	5			3	3					
	5½	807½	CG	"	35			65	5			2	3			x		
	8	815½	CG					100				3	2					small folds
99	16½	832	CG					100				3	1					fault zone
																		isol. foss.
100	2	834	G	cs-f	80			20	4			3				x		
	14	848																covered
	7½	855½	C	cs-f	30	35		35	4			2			2	x		
	8	863½	C	"	20			80	2			2			1	x		
	15	878½	C	"	60	tr.		40	5			2	4					
105	6½	885	CG	cs		85		15		3/4		2	2					
	8	893	C	cs-f	5	85		10	1½	1		2						N.80E. 64N.
	41	934																covered
	52	986	CJ	cs-f	5	85		10	2	1		2			1			pwr.lines
	1	987	C	"	60			40	5			2				x		N.85E. 63N.
110	13	1000	C	cs		85		15		2		2						
	22	1022	C	cs-f	20	65		15	3	3		2						
	4	1026	C	"			30	70			3/4	2			2			pwr.pole 53
	22	1048																covered
	6½	1054½	DC	cs-f	25			75	1½			1		s				argill.
115	5½	1060	DC	"	15		10	75	3		3/4	2						clay galls
	6½	1066½	D	"	5		10	85	3		3/4	2		s				on hillside
	4½	1071	D	"	75			25	2			1		s	3			in road-cut
	1	1072	D	"	100				12									
	5	1077	DG	"	5	80		15	5	1½		1	4					
120	4	1081	DG	cs		95		5		1		2						
	4½	1085½	DG	cs-f	65	25		10	4½	1				s				
	2	1087½	DCG	cs		60		40		2		1	2					
	6	1093½	DG	cs-f	30	20		50	3½	1½		1	3	s				
	7	1100½	DCG	"	10	65	tr.	25	1½	1				s				
125	4	1104½	DC	"	70	10		20	3	1		1		s				
	5	1109½	DCG	"	30	10	tr.	70	1½	1		1		s				

Stratigraphic Description					JUNIATA RIVER SECTION													
Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
127	2½	1112	DG	cs-f	70	20		10	5	1½		2	4					
128	3	1115	DG	cs		10		90		1		2						
	1	1116	GD	cs-f	100			PTG	4									
130	3	1119	DG	"	30	20		50	3	2		2						argill.
	4	1123	DG	"	20	70		10	4	2		2	2	s	4			clay galls
	5½	1128½	DG	"	10	80		10	3½	2								
	12½	1141	DCG	"	15	60		25	4½	3		2	2					argill.
	2	1143	DG	"	90			10	7			1			3			
135	2½	1145½	CD	"	40			60	2½			1						
	6	1151½	DG	"	65	10		25	4½	2		1	3					
	3	1154½	CD	"	30	20		50	4	1½		2						
	3	1157½	DG	"	70	20		10	5	3		1	4					
	1½	1159	DCG	"	25		15	60	1½		3/4	2	4					
140	5½	1164½	CD	"	85			15	5			1			4			
	2½	1167	CD	"	20	40		40	2½	1		1			3			
	3	1170	CD	"	50	15		35	5	1		1						
	4½	1174½	CD	"	30	20		50	4	1½		1	2	s				
	5	1179½	CD	"	80			20	5½			1						Pwr.pole 54
145	4	1183½	CD	"	60		20	20	2½		3/4	1						vert. dip
	10	1193½	CD	"	20			80	2			1						on hillside
	10	1203½	CD	"	10			90	2			1						
	8½	1212	DI	"	50	40		10	4	2		2						monocline
	11½	1223½	CDI	"	60		20	20	4		3/4	2						in road-cut
150	6	1229½	CDI	"	60		30	10	4		3/4	1	3	s				
	5	1234½	DI	"	95			5	2½			2						vague bdg.
	7	1241½	CI	"	60	10	20	10	3½	1½	3/4	1						
	3	1244½	CG	"	10	80		10	2	1		2						
	1½	1246	DG	"	90			10	5			1						
155	6½	1252½	CG	"	35	10		55	2	1		1		s				
	12	1264½	CDG	"	80			20	7			3						
	12	1276½	CDG	"	40			60	2½			1						on hillside
158	8½	1285	CDG	"	90			10	5½			1						in road-cut
																		at culvert
159	3	1288	CG	cs-f	30	40		30	3½	1½								
160	8	1296	CG	"	85			15	6			1						
	3½	1299½	CG	"	25	55		20	2½	1		2						
	7½	1307	CG	"	20	65		15	2	1		1						
	6	1313	CG	"	60	30		10	9	1		2						
	3	1316	CG	"	10	75		15	2½	1		2	4					
165	9½	1325½	CG	"	50	35		15	2½	1		2			3			
	7½	1333	CG	"	65	25		10	4½	1½		2						Pwr.pole 55
	15	1348	CDG	"	25	65		10	2½	1		2			4			
	5	1353	CGD	"	50	45		5	6	1½		2		s				
	12	1365	CG	"	25	65		10	2½	1		2						
170	6	1371	CG	"	60	30		10	3	1½		2			3			
	15½	1386½	CG	"	15	55	15	15	3	1½	3/4	2	3		3			

Stratigraphic Description — JUNIATA RIVER SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
172	3½	1390	CG	cs-f	50	20	10	20	4½	1	½	3			3			
173	16	1406	CG	cs-f	20	40	20	20	3	1	3/4	2						
	2½	1408½	CG	"	70	10		20	5½	1		1						
175	6½	1415	CG	"	25	25	10	40	3	1½		2						
	3½	1418½	CB	"	45	20		35	7	1		2						
	5	1423½	CF	"	60			40	3½			1						
	3	1426½	CBF	cs		30		70		1		1						
	4	1430½	CF	cs-f	50	20		30	2	1½		1		s				
180	1	1431½	CF	"	100				14					s				
	11½	1443	CBF	"	50		20	30	2		½	2			2			vague bdg.
	8	1451	CB	"	35	40	10	15	3½	2½	½	2	3					
	7	1458	CBF	"	80			20	6			2	3					conv. bdg.
	2	1460	CF	cs		75		25		2		2						
185	8	1468	CF	cs-f	70	10		20	3	2		2	3		4			
	4	1472	CF	"	80	10		10	6	1		2						
	6½	1478½	CB	"	35	15		50	1½	1		1						
	1½	1480	C	"	100				18									
	3	1483	CB	"	40	20		40	2	1½		1						
190	2	1485	CB	cs		20		80		1		1						argill.
	14⅓	1499⅓	CB	cs-f	90			10	5			2						vague bdg.
	18⅓	1518⅓	CB					100				3						
	11	1529	B					100				2						
194	12	1541	B					100				2						
																		long covered interval. end section

Section 10, Millerstown

The Trimmers Rock Member is exposed dipping south along the Pennsylvania Railroad about 1¼ miles south-southeast of Millerstown, in Tuscarora Township, Perry County. The exposures occur in the Millerstown 15-minute quadrangle on the west bank of the Juniata River in railroad cuts, small stone quarries, and road-cuts.

Below the lowest red shales of the Catskill at a point 3700′ south of 40°32′30″N and 5900′ west of 77°07′30″W, 1220 feet of the Trimmers Rock is exposed. The lowest rocks exposed occur in cuts on a paved country road at a point 2250′ south of 40°32′30″N and 3350′ west of 77°07′30″W. A small stream valley separates the lowest Trimmers Rock from dark gray shales of the Harrell Shale.

Stratigraphic Description — MILLERSTOWN SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
	18		red	cs-f	20			80	3			1						Catskill
																		R.R. cut
1	15½	15½	CG	cs-f	10	50		40	2	1½		3	4					
	15	30½	CG	"	80	10		10	6	1½		3	1					Pwr. pole
	48	78½	CG	"	10	10		80	2	1		3						
	21	99½	C	"	30	50		20	3	2		3						
5	21½	121	C	"	35	35		30	7	1		3						
	24	145	CJ	"	80	10		10	8	2		3		L				culde sac
	19	164	C	"	75			25	7			3		L				on hillside
	11	175	C	"	25			75	3			3						
	13	188	CDI	cs		40		60		3		3						
10	22½	210½	DIC	cs-f	20	10		70	2	1		3						20% covered
	12	222½	CDI	"	15		tr.	85	1½			1						
12	28	250½	C	"	15	35		50	2½	1		3						end cul
																		de sac
13	21	271½	C	cs-f	15	25		60	3	1		1						R.R. cut
	9	280½	CKI	"	25			75	1½			1						spring
15	10½	291	C	cs		10		90		2		1			4			
	13	304	C	cs-f	10	65		25	4	1		1						
	10	314	C	"	95			5	6			PTG	2					
	5	319	C	"	80	5		15	4	1		3	2					
	9½	328½	C	"	40	35		25	5	1½		3	3					
20	9	337½	CJ	"	90	5		5	7	2		PTG	4					
	3½	341	CJ	"	95			5	8			PTG	1					
	14	355	CJ	"	80	5		15	4	1		3	1	s				
	2½	357½	CJ	"	75			25	7			3						
	8½	366	J	"	5	10		85	2	1½		3						
25	4	370	GC	"	90			10	5			3	1					
	2½	372½	J	"	60			40	5			3				x		
	12½	385	JC	cs		30		70		1½		3						
	5½	390½	J	cs-f	15	55		30	2	1		3	1					
	2	392½	J	"	85			15	7			3						
30	5½	398	J	cs		50		50		1		3						
	9½	407½	J	"		70		30		1		3						
	13	420½	JC	cs-f	15	50		35	3	2		3	2	s	4			
	2½	423	J	"	60			40	4			3			4	x		Pwr. pole
	11	434	J	cs		50		50		3		3						high incut
35	4	438	J	cs-f	100				7							x		
	5	443	JC	"	65			35	7			3						
	9	452	JGC	"	50	15		35	5	2		3	2					
	21	473	C	cs		10		90		1		3	1					
	19	492	C	cs-f	70			30	5			3				x	x	eroded base
40	26	518	C	cs		50		50		3		3						Pwr. pole
																		20% covered
41	39	557	C	cs-f	10	70		20	2	2		3	3					
42	3	560	C	"	70			30	6			3						

Stratigraphic Description — MILLERSTOWN SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
43	16½	576½	C	cs-f	5	40		55	2	1½		3	4					
	14	590½	C	"	15	35		50	3	2		3						
45	4	594½	C	"	75			25	7			3						
	11½	606	C	"	20	30		50	2½	2		3						
	13	619	CB	cs		20		80		2		3						
	11	630	B	cs-f	90			10	9			PTG				x		
	22½	652½	B	"	50		tr.	50	1½			1			4			silty shale
50	21	673½	C															sheared
																		shale, fault
51	18½	692	C	cs-f	40			60	4			3						
	10½	702½	B	"	70			30	7			1	2					
	20	722½	B	"	10			90	2			3						
	11	733½	B	"	60			40	2			3		s				
55	12½	746	B	"	75			25	8			3						
	8½	754½	B	cs		60		40		1		3						
	6	760½	DI	cs-f	85			15	6			3						
	3	763½	DI	"	10			90	2			1						silty shale
	9	772½	CGI	"	85			15	12			1						N.70E. 58S.
60	37½	810																covered
	6	816	C	cs-f	60			40	8			3						N.75E. 63S.
	5⅓	821⅓	C	"	80			20	14			1						
	11	832⅓	C	"	75			25	12			1						
	28	860⅓	C	"	75			25	9			3						old quarry
65	2	862⅓	DI	f-m	100				24									graded bdg.
	14	876½	DI	cs-f	70			30	3			3						
	17	893⅓	C	"	85			15	3			3		s	2			
	9	902⅓	C	"	80			20	3			3		s	2			ledge
	25	927⅓	C	"	15		tr.	85	1⅓			3						silty shale
70	12	939⅓	CB	"	75			25	2			3			4			
	9	948⅓	CB	"	40		tr.	60	1⅓			3						
	10½	959	CB	"	70			30	5			3						
	6	965	C	"			10	90			3/4	1						
	4	969	CI	"	80			20	6			3						
75	14⅓	983⅓	CI	"	35			65	5			3						clay-rich
	12	995⅓	CI	"	60			40	4			3						N.75E. 50S.
	7⅓	1003	CI	"		20	15	65		1	3/4	3						end quarry
78	50	1053																covered
																		stream
																		valley
79	9	1062	DIG	cs-f	10			90	2			3						at culvert
																		on paved
																		road
80	10	1072	GI	cs-f	35			65	5			3						N.70E. 64S.
	8½	1080½	G	"	40			60	3			3						clay-rich
	13	1093½	CI	"	65	25		10	8	2		3						isol. foss.
83	8½	1102	CI	"	25		tr.	75	1⅓			3						clay-rich

Stratigraphic Description — MILLERSTOWN SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
84	8	1110	CB	cs-f	75			25	6			3						
85	2	1112	B	"			10	90			3/4	3						
	5	1117	B	"	25		tr.	75	1½			1						
	1	1118	DIC	"	90			10	3			3						
	5½	1123½	CDI	"			40	60			3/4	3						
	4½	1128	DIC	"	80			20	4			3						irreg. bdg.
90	1	1129	DI					100				1						
	6	1135	DI	cs-f	90			10	4									
	3	1138	DIG	"	20		tr.	80	2			2						
	3½	1141½	DI	"	60			40	8			2	3					clay-rich
	20	1161½	GDI	"	25			75	3			3						
95	5	1166½	G					100				3						clay-rich
	12½	1179	G	cs-f	50			50	4			3						
	21½	1200½	GDI	"	35			65	3			2						
98	22	1222½	GDI	"	10		tr.	90	1½									clay-rich
																		N.70E. 54S.
																		covered to
																		Hamilton
																		shale
																		across
																		valley

Section 11, Liverpool

The Trimmers Rock was studied in road-cuts and natural exposures along Routes 11 and 15, 3 miles north of Liverpool in Liverpool Township, Perry County. The basal Catskill red shales dip south in road-cuts at a point 7550′ south of 40°37′30″N and 1200′ east of 76°57′30″W on the Millersburg 7½-minute quadrangle. A section including 819½ feet of Trimmers Rock was measured in the road-cuts, but it was necessary to climb the bluff to measure the following 297½ feet. The lower portion of the section was measured along the highway cut and in natural exposures behind the roadside buildings.

The northernmost outcrop, adjacent to a small unnamed stream, reveals dark gray shales in the core of an anticline. Estimated thickness of the shales is not reliable because of structure. A long covered interval showing occasional outcrops of very dark gray shale which weathers buff was measured to a point where float blocks of fossiliferous limy shale were found. This questionable occurrence of Tully Limestone lies along the north side of a farm road about 3950′ south of 40°37′30″N and 250′ east of 76°57′30″W.

Stratigraphic Description — LIVERPOOL SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
	6		red					100				1						Catskill,
																		in road-cut
1	17	17	JH					100				1						silty shales
	11	28																covered
	28	56	D					100				1						Pwr pole 43
	18	74																covered
5	23½	97½	DI	cs-f	5			95	9			1						20% covered
																		on hillside
6	71	168½	DI	cs-f			tr	100				1						in cut, base
																		at culvert
7	45½	204																covered
	19½	223½	DG	cs-f	40			60	4			1		s				Pwr. pole 44
	26	249½	DI	"	5			95	1½			1		s				sheared
10	3	252½	J	"	60			40	2			1		s				
	2½	255	J	"	10	70		20	3	1½								
	2	257	J	"	80	15		5	2	1		PTG		s	4			6" sets
	2	259	J	cs		85		15		1		PTG						
	1	260	J	cs-f	90			10	3			1						
15	12½	272½	J	cs		80		20		1		3		s				isol. foss.
	5	277½	D	cs-f	75	5		20	6	1		2	1		4			isol. foss.
	15	292½	DJ	"	10	60		30	2⅓	2		2	2	s				iron stain
	12½	305	DJ	"	20	30		50	2½	1½		2		s	3	x		
	7	312	DJ	"	75	15		10	6⅓	2		2	1		3	x		
20	3	315	D	"	95			5				3				x	x	eroded base
	1	316	D	cs		90		10		1½		3						sheared
	8	324	J	silty				100				3						
	13	337	DJ	cs-f	70			30	12			2				x	x	eroded base
	5	342	D	"	95			5	6			1		s	3	x		
25	5	347	DJ	"	25	55		20	3	2½		2			4			iron stain
	3½	350½	DJ	"	35	55		10	5	3		2	3		4			iron stain
	3½	354	DJ	cs		90		10		2		2				x		iron stain
	6	360	DJ	"		90		10		4½		2	4					culvert
	6½	366½	DJ	cs-f	65	20		15	7	3		2	2			x		iron stain
30	3½	370	DJ	"	10	60		30	3	3		2						iron stain
	12	382	D	"	15	75		10	4	5		1	2		3	x		argill.
	6	388	DJ	silty				100				3						iron stain
	5	393	J	cs-f	80			20	7			2	3			x	x	O.T. sole
	4	397	DJ	"	80	10		10	5	1½		2	3			x	?	eroded base
35	5	402	DJ	"	30	50		20	4½	3½		2		s	4			Pwr.pole 45
	7½	409½	D	"	5	65		30	2⅓	2		2				x		sheared
37	4	413½	DJ	"	70			30	9			2				x	?	eroded base
																		iron stain
38	1½	415	J	cs-f	100				18?									
	11⅓	426⅓	DJ	"	10	65		25	2	2⅔		2	4		2	x		iron stain
40	1⅓	428	DJ	"	25	60		15	3	1⅓		2	2					iron stain
41	4	432	DJ	"	5	20	tr	75	1⅓	1		2						

Stratigraphic Description — LIVERPOOL SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
42	3	435	D	cs-f	60			40	4			3	1	s				argill.
	2½	437½	D	"	35			65	3½			2						30% covered
	4	441½	D	"	10	80		10	3	2		2						
45	10½	452	D	"	5	80		15	1½	1½		2		s		x		
	11	463	D	"	5	30		65	2	1		2		s		x		
	2½	465½	D	"	5	20		75	1½	1		2				x		argill.
	4	469½	D	"	30	50		20	6	1		2	3	s		x		argill.
	7½	477	DJ	cs		10		90		1		1						iron stain
50	49	526	DJ	cs-f	10	5		85	2	1		1						60% covered
	12	538	DJ	"	10	20		70	3	1		2		s				iron stain
	9	547																covered
	10½	557½	D	cs-f	15	70		15	4	2½		2	4	s		x		argill.
	4	561½	DJ	"	75	15		10	3	2		2	1		4			
55	5½	567	DJ	"	20	60		20	3	2		2	3		3			argill.
	11	578	DJ	"	60	25		15	3½	1½		2	4	s		x		culvert
	3	581	DJ	"	5	70		25	2	2½		2						
	9	590	DJ	"	15	75		10	3½	3		2						
	10	600	DJ	"	30	55		15	3½	2		2	3					Pwr. pole 4
60	6½	606½	D	cs		90		10		2			2	s	4	x		
	3	609½	D	cs-f	75	10		15	5	1½		2	1					
	7	616½	DJ	"	20	35		45	2½	1		2	3	s				irreg. bdg.
	9½	626	D	"	55	30		15	3	1½		2	3	s	3	x		
	3½	629½	CJ	"	15	65		20	3½	2		2	1	s	2	x		
65	4	633½	D	"	30	55		15	3	1½		2	1	s				
	8½	642	DCJ	"	10	70		20	3	2		2	2	s				
	14	656	CJ	"	5	65		30	2	2		2	3					
68	10	666	CJ	cs		20		80		1		1						end large
																		cut
69	16	683	CJ	cs-f	20	10		70	4	1		1						cul de sac
70	13	695																covered
	18	713	DI	cs-f	10			90	2			1						in low cut
	11	724																covered
	11	735	DIJ	cs-f	40			60	6			1						on hillside
	14	749	DI	"	70			30	5			1						
75	8	757	DI	"	20			80	2			1						in low cut
	15	772	DI	"	75			25	4			1	4					
	8½	780½	DI	"	95			5	40?			1						contorted
	5½	786	D	"	60			40	4			1						on hillside
	9	795																covered
80	22	817	DI	cs-f	15	5		80	2	1½		1						
	2½	819½	D	"	100				30?									Pwr.pole 47
	8	827½	C	"	50	10		40	12	3		1						on hillside
	5	832½	DI	"	25			75	2			1		s	2			silty shale
	1½	834	C	"	100				9							x		
85	7½	841½	C	"	30		tr	70	1½			1			1			silty shale
86	3½	845	DIG	"	60			40	4			1			3			3" sets

Stratigraphic Description — LIVERPOOL SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
87	6	851	C	cs-f	40		tr	60	1½			1			2			
	3½	854½	C	"	75			25	3			1			3			
	2	856½	C	"	75		tr	25	1½			1						
90	4	860½	C	"	25		tr	75	1½			1			1			silty shale
	1½	862	CD	"	80			20	2			1			1	x		
	2	864	C	"	15			85	1½			1			4			
	4½	868½	C	"	50			50	1½			1						
	1½	870	DI	"	90			10	5			1						
95	11	881	C	"	70	15		15	3	1		1		s	2			
	5	886	CI	"	20		tr	80	1½			1		s	3			
	1	887	CI	"	70		tr	30	1½			1	4					
	4	891	CI	"	40			60	1½			1			4			
	1½	892½	C	"	65		tr	35	1½			1	3					
100	6	898½	CI	"	25			75	1½			1			3			
	2½	901	CI	cs			60	40			½	1						
	2	903	C	cs-f	30		tr	70	1½			1						20% covered
	10	913	CI	"	80			20	3			1	4	s				N60E59S —
	7	920																covered
105	2	922	IC	cs-f	20		tr	80	1½			1						
	2	924	CI	"	70			30	1½			1						
	106½	1030½																covered
	3½	1034	C	cs-f	10			90	1½			1						
	25	1059	C	"	10			90	1½									30% covered
110	30	1089																covered
	13	1102	C	cs-f	50			50	2			1						70% covered
	3	1105	C	"	65			35	2			3						
	12	1117	CI	"	15		tr	85	1½			3						
	17	1134																covered
115	79	1213	C	cs-f	30			70	3			3	4		2			in road cut
	1	1214	C	"	100				12									
	3	1217	CD	"	35	65			2	1								
	2½	1219½	CD	"	30	70	tr		1½	1								
	38	1257½	D	"	25	75			2	1					3			20% covered
120	3½	1261	CD	"	70	30			4	1			2		3			
	4½	1265½	CD	"	60	35		5	3	1		3	1					
	5	1270½	D	"	20	75	tr	5	1½	1		3	1					
	10	1280½	CD	"	80	10		10	4	1		3		s				
	8½	1289	DC	"	15	80		5	2	2		3						
125	14½	1303½	D	"	65	25		10	4	1½		3	3	s				Pwr.pole 49
	2	1305½	D	"	15	65		10	5	2		3				x		
	3	1308½	D	cs		100				1								
	6	1314½	D	cs-f	30	60		10	2	1½		3		s				
	23½	1388	D	"	85	10		5	3	1		3		s		x		conv. bdg.
130	7	1345	D	"	30	65		5	1½	1		3						
	8	1353	D	"	55	40		5	5	1½		3						
132	9½	1363½	D	"	75	20		5	3	1		3	3					

Stratigraphic Description					LIVERPOOL SECTION													
Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithalogy				Average Bedding Thickness			Fissility	Fossils	Troce Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
133	11½	1374	D	cs-f	30	65		5	2	2		3	1					
	7½	1381½	D	"	20	70		10	2	5		3						
135	11	1392½	D					100				3			4			
	5	1397½	D	cs-f	80	20			6	2								
	14½	1412	D	"	15	70	10	5	3	2	½	3	3		2	x		
138	1½	1413½	D	"	30			70	9			3				x		discont.
																		high in cut
139	36	1449½	D	cs-f	15	70	10	5	4	2	½	3	3		2	x		
140	24	1473½	D	"	25	70	tr	5	6	3		3				x		
	27	1500½	D	"	5	75	5	15	2	4	¼	3				x		Pwr.pole 50
	6½	1507	CD	"	45	25		30	3½	3		2				x		
	8½	1515½	C	"	5	80		15	2	3		2		s				
	½	1516	C	"	100				5									
145	14	1530	C	"	10	70		20	3	2½		2						
	9½	1539½	C	"	5		15	80	2		½	3						fault (?)
	10	1549½	C	"	10	50		40	3	1½		2						
	1	1550½	C	"	100				9				1					
	9	1559½	C	"	5	55	5	35	3	2	3/4	2				x		
150	2	1561½	C	"	40	45	5	10	7	3½	½	2		s		x		laminated
	5½	1567	C	"	5	90		5	4	2½		2						
	8½	1575½	C	"	15	75		10	4½	3		2				x		irreg. bdg.
	2	1577½	CD	"	80	5		15	1½	1		2		s		x		
	6½	1584	C	"	5	85		10	2	1½		2						irreg. bdg.
155	8	1592	C	silty				100				3		s				small fault
	5	1597	C	cs		90		10		3		2		s		x		
	4	1601	C	cs-f	30	60		10	5	3		2						
	4½	1605½	C	"	5	75		20	2½	2		2			4			
	2	1607½	C	"	90			10	7			2						
160	8	1615½	C	cs		25		75		1½		1						
	2	1617½	CD	cs-f	80	10		10	5½	2		2				x		
	5½	1623	C	"	5	80		15	2½	2½		2			4	x		
	2	1625	CD	"	90			10	10			PTG						
	3	1628	C	"	75	15		10	3	1½		2				x		
165	8	1636	C	"	20	55		25	3	1½		2			4			
	1	1637	CD	"	100				5½									
	8	1645	C	cs		15		85		1		2						argill.
	3½	1648½	CD	cs-f	80			20	6			1				x		
169	16	1664½	CDI	"	25	5		70	3½	1		1		s				end large
																		cut, Pwr.
																		pole 51
170	32	1696½		cs-f	20			80	2			1						on hillside
171	153	1849½	CDB	"	5		5	90	2½		½	1		s				silty shale,
																		on hillside,
																		10% covered
172	10½	1860	CB	cs-f	70			30	2			1		s				behind bldg.
173	13	1873	CD	"	25			75	2			1						

Stratigraphic Description — LIVERPOOL SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
174	9	1882	CB	cs-f	65			35	4			1						
175	11½	1893½	CB	"	10		tr	90	1½			1						
	6	1899½	CB	"	25			75	1½			1		s		x		behind bldg.
	49	1948½	BC	"	5		5	90	1½		½	1						Burket (?)
	5	1953½	BC	"	20			80	2			1						
179	6½	1960	B					100				2						clay-rich
																		core of
																		anticline
180	1½	1961½	BC	silty				100				3						
181	10	1971½																syncline
																		covered
182	10	1981½	BC					100				3						50% covered
	12	1993½	BC	cs-f	10		tr	90	1½			1						N65E59S →
	300	2293½																covered
185																		float of
																		limey lt. to
																		med.gy.sh.
																		in bank of
																		stream.
																		Tully (?)

Section 12, Red Cross

The Trimmers Rock is exposed on the south limb of a shallow syncline in road-cuts along Route 225 about ¾ mile south-southwest of the village of Red Cross, Jackson Township, Northumberland County. At a point about 2400′ south of 40°42′30″N and 100′ east of 76°47′30″W, on the Pillow 7½-minute quadrangle, the lowest red shales of the Catskill Formation are exposed.

Two long covered intervals limit the usefulness of the Red Cross section. In addition the base cannot be precisely located because of poor exposures and structure. The base of the measured section lies at a point along the old roadway 4650′ south of 40°42′30″N and 1000′ east of 76°47′30″W. In the next exposure, 600 feet south, the Trimmers Rock is involved in an anticline.

The Red Cross section was measured to provide an intermediate section between those at Liverpool and Shamokin Dam.

Stratigraphic Description — RED CROSS SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc	Movement	Miscelloneous
	2½		red	cs-f	20			80	2			1						Catskill
																		road-cut ce-
																		ment culvert
1	10	10	G	cs-f	10			90	2			1						
	122	132																80% covered
	10	142	G	cs-f	70			30	2			1						N80E46N ⊥
	18½	160½																covered
5	2	162½	G	cs		100				1								
	9½	172	G	cs-f	60			40	4			1				x	x	ang. blocks
	1½	173½	G	"	30			70	2			1						contorted
	7½	181	G	cs		70		30		1½		1						
	5	186	JG	cs-f	90			10	7			1						
10	6	192	G	cs		90		10		1½		1						
	1½	193½	DI	cs-f	100				17							x		
	11½	205	C	"	10	70		20	4	2		1			3			
	5½	210½	CG	"	20	20		60	2	2		1						
	1	211½	G	"	100				6					s				
15	3	214½	C	cs		70		30		1		1						
	4	218½	G	cs-f	50			50	7			1						xeroded base
	3½	222	JD	"	100			PTC	5						4			
	8	230	JD	"	65	10		35	6	3		1						
	4	234	JD	cs		100				2								
20	2	236	JD	cs-f	100				8							x		
	9½	245½	G	"	20	60		20	2	1		1						
	8½	254	G	"	30	10		60	2	1		1						N80E37N ⊥
	64½	318½																covered
	1½	320	G			tr		100				1						borrow pit
25	21	341	G	cs-f	10			90	2			1						20% covered
	8	349	J	"	25	10		65	1½	1½		1			4			isol.foss.
	5½	354½	G	"	15			85	1½			1						
	4	358½	G	"	65			35	4			1						
29	228½	587																covered
																		S. across
																		road & stream
																		valley
30	7½	594½	CG	cs-f	25			75	2			1						N85E38N ⊥
	4	598½	C	"	25	15		60	2	1		1						road cut
	4	602½	C	"	75	10		15	8	2		1	3			x		
	2½	605	G					100				1						
	2½	607½	G	cs-f	35			65	3			1						
35	3	610½	C	cs		10		90		3		1						
	18	628½	C	cs-f	55	40		5	5	3		1	1					
	2½	631	CJ			80		20		3		1	1					
	6½	637½	CI	cs-f	70	10		20	7	2		1						
	8	645½	CI	"	20	60		20	3	3		1						
40	3	648½	G	silty				100				3						isol. foss.

Stratigraphic Description — RED CROSS SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
41	4	652½	GF	cs-f	85			15	6			1				x		
	2½	655	GF	cs		30		70		3		1						
	10½	665½	GF	cs-f	75	10		15	5	1½		1		s				
45	8½	674	GF	"	25			75	3			1						
	6½	680½	GF	"	5	75		20	2	2		1	2					
	18½	699	C	"	80			20	5			2					x	ang. blocks
	11	710	GF	"	50	10		40	3	2		1						N85E45N ←
	15	725	C	"	80			20	5			2					x	ang. blocks
50	437	1162																covered
																		across
																		stream
51	34	1196	GF	cs-f	40	35		25	6	2		1						culvert,
																		small bank
52	27½	1223½	GF	cs-f	15	10		75	2	1		1						20% covere
	12	1235½	CGF	"	15	75		10	4	5		1						
	4	1239½	GF	"	95			5	12			1						laminated
55	3	1242½	GF	"	20	40		40	4	5		1						
	4½	1247	GF	"	70			30	6			1				x		
	23½	1270½	CGF	"	25	55		20	5	3		1	2		4			
	5½	1276	GF	"	100				30?									
	8½	1284½	GF	"	85			15	10			1			3	x		laminated
60	10½	1295	C	cs		90		10		3		2	3					
	10	1305	GF	cs-f	95			5	9			1			4			3"sets
	10	1315	C	cs		90		10		3		1	3					
63	5	1320	GF	cs-f	80			20	5			1						small tect
																		folds
64	16	1336	GFC	cs-f	90			10	8			1						clay-rich
65	8	1344	GF	"	60	20		20	6	4		1			3			
	9	1353	C	cs		90		10		3		1						
	3½	1356½	C	cs		90		10		3		1	4			x		
	7½	1364	C	cs		90		10		3		1						
	7½	1371½	GFC	cs-f	60	30		10	14	4		1	2		4			
70	5½	1377	GFC	"	10	75		15	7	5		1	2		4			laminated
	19	1396	GFC	"	95			5	10			1			3			laminated
	17½	1413½	C	"	25	60		15	8	5		1	4		2			
	15	1428½	C	cs		85		15		3		1						
	11	1439½	C	cs-f	10	85		5	6	3		1	3		2			pseudo-fis
75	20½	1460	C	"	15	75		10	8	2		1	2		4			
76	18	1478	CGF	"	10	80		10	6	3		1	2					old roadcu
																		above & toE
77	15	1493	CGF	cs-f	60	35		5	8	3		1						
	1½	1494½	CGF	"	60			40	8			1				x		
	5	1499½	C	"	15	80		5	5	3		1						
80	9	1508½	CIH	"	65	20		15	7	3		1						
	4	1512½																covered
82	12	1524½	C	cs-f	40	30		30	9	2		1						end cut

Section 13, Shamokin Dam

Section 13 was studied in railroad cuts along the west side of the Susquehanna River near Shamokin Dam, Monroe Township, Snyder County. The upper portion of the section is involved in a series of folds at this locality, and a long covered interval occurs between the lowest red beds observed and the top of the measured section. Compilation of running footage was made from the top of the highest-exposed north-dipping unit, which is also continuous to the main body of the section. The top of the measured section lies on the north bank of a small stream at a point about 11,600′ north of 40°50′00″N and 7700′ east of 76°50′00″W on the Sunbury 15-minute quadrangle.

From this point south, the section was measured in a north-dipping homocline. At the southernmost railroad bridge over Route 11 the section on the railroad ends, and measurements were continued in cuts along Route 11. The last exposure in the measured section occurs behind a restaurant adjacent to the traffic circle, at a point about 8200′ north of 40°50′00″N and 6100′ east of 76°50′00″W.

Stratigraphic Description					SHAMOKIN DAM SECTION													
Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneou
					I	II	III	Sh	I	II	III							
	4		red	cs-f	15			85	2			2		s	4			Base of C- skill
1	17½	17½	C	f	5		tr	95	1			1	4	s				grded. bd paper shal
2	5½	23	C	cs-f	20		tr	80	1			1			4			color lam.
3	18	41	C	"	5		tr	95	1			1						paper shal color lam.
4	3	44	C	cs-f	20	15		65	3	1		3						
5	3	47	CF	cs		25	tr	75		1		1						color lam.
	3½	50½	FG					100				3						
	4	54½	C					100				1						
	6	60½	C	cs		40		60		2½		2						
	5	65½	FG	cs-f	30	50		20	3	2		3	4					N60E65W +
10	12½	78	FG	"	10			90	1½			2	4		3			silty shal
	1	79	DI	"	100				12									
	49	128	DGK	"	5			95	1½			2		s				R.R. sign
	1½	129½	F	"	80			20	4			1						
	4½	134	DG	"	15			85	3			1						
15	9	143	CF	"	10			90	2			1						
	14	157	DG	"	5	5		90	1½	½		1						
	1	158	DI	"	100				12					s				laminated
	2½	160½	K					100				1						
	2½	163	DG	cs-f	100				30									argill.
20	2	165	DGJ	"	80			20	6			3						red stain
	4	169	DI	"	95			5	14			PTG						laminated
	2½	171½	DI	"	75			25	7			1						
	38	209½	CF	"	5	15		80	1½	1½		2						argill.
24	4½	214	FG	cs		40		60		2½		2						
25	4	218	DFI	cs-f	45			55	5			2			4			silicious
	5	223	C	"	10			90	3			3						argill.
	2	225	G	"	100				8									N75E45N +
	1	226	C					100				3						silty
	17½	243½	G	cs-f	95			5	30?			PTG			4	x		
30	5	248½	G	"	5			95	1½			1						
	2	250½	G	"	100				23					s				
	5	255½	G	"	5	20		75	1½	1		1						
	3	258½	GF	"	65	10		25	10	1			3					
	7	265½	GF	"	25	25		50	3	1		2						
35	4	269½	F	"	100				46					s				
	14½	284	F				tr.	100				1			4			pencil sh.
	1	285	F	cs-f	100				12									
	5	290	F					100				3						clay-rich
	2	292	C	cs-f	50			50	5			3				x		
40	3	295	C	cs		15		85		1		1						
	17	312	C	cs-f	20	40		40	4	2		3		s				
	6	318	C	"	30	5		65	1½	1½		1						

Stratigraphic Description — SHAMOKIN DAM SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
	5½	323¼	C	cs-f	10	55		35	1½	5		2						
	9	332¼	C	"	10	10		80	2½	3		1						
5	4	336¼	C	cs		75		25		5		1						
	9½	346	C	"		5		95		2		1						
	4½	350½	C	cs-f	70	20		10	6	2		2		s	2	x		
	3	353½	C	cs		20		80		2		1			2			
	13	366½	C	cs-f	80			20	6			3				x	x	eroded base
0	19	385½	C					100				1						pencil sh,
	15	400½	C	cs-f	10	10	tr	80	1	1		2		s	3			color lam,
	24½	425	C	"	15	30		55	2½	2		2		s				
	17½	442½	C	"	10		tr	90	5			3	4	s	3			silty shale
	2	444¼	C	"	50			50	6			3			3			
5	9	453¼	C	"	10			90	1½			3			4			
	7	460½	C					100				3		s				
	26	486½	C	cs-f	35	40		25	3	2		3		s	2			
	2	488½	C	"	90	5		5	11	2½		PTG			2			laminated
	12	500½	C	"	5	5		90	1½	1		3	4	s		3		
0	6	506½	C	"	5		tr	95	2			3						
	13½	520	C	"	10			90	2			3			3			
	7½	527½	C	"	30	20		50	4	2		3			2			
	10½	538	C	"	40	25		35	9	1½		2			2			
	9	547	C	"	45	10	tr	45	4	3/4		2			3			
5	5	552	C	"	5			95	1½			3			3			
	3	555	C					100				1						
	5	560	C	cs-f	45			55	3			3		s				
	7	567	C	"	5			95	2			3						
	6½	573½	C	"	10			90	2½			3			4	x		
0	6	579½	C	"	5			95	2			3			4			
1	7½	587	C	"	60	5		35	4½	1		3		s	4			
	10	597	C	"	5	10	tr	85	1	1		3			4			
	9	606	C	"	5		tr	95	1½			3	3	s	3			
	12½	618½	C	"	35	40		25	3	1		2			2			
5	10½	629	C	"	5	25	5	65	3	1½	½	2			2			
	4	633	C	"	70	20	tr	10	3½	1½		3		s	2			
	5½	638½	C	cs		10	tr	90		1		2						
	13½	652	C	cs-f	15	5	tr	80	2½	1		3		s	4			
	14½	666½	C	"	45	10		45	4½	1		3	4	s	3	x		
)	8½	675	C	"	60	5		35	5	1		3			3			iron rail
																		at top cut
	2	677	C	silty				100				2						
	11½	688½	C	cs-f	50	20		30	3½	1		2			3			Pwr.pole,no
																		number
3	6	694½	C	"	40	25	tr	35	5½	1½		3			2			silty shale
	16	710½	C	"	20	15	tr	65	5	2		3			2	x		silty shale
	1	711½	C	"	75			25	7½			1						
	5	716½	C	"	60	15		25	3½	1		2			3			

Stratigraphic Description					SHAMOKIN DAM SECTION													
Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscelloneous
					I	II	III	Sh	I	II	III							
87	9½	726	C	cs-f	35	30		35	3	1		2			4			
	4½	730½	C	"		40	s	55		1	½	2			3	x		
	2	732½	C	"	70	10	tr	20	3½	1		2			2			
90	3	735½	C	cs		35	tr	65		1		2			4			
	6½	742	C	cs-f	60	5		35	6	1		2		s	4			
	5½	747½	C	"	20	10	tr	70	3	1		2		s	4			
	8	755½	C	"	70	5		25	8	1		3	4					
	7	762½	C	"	25	30		45	4	1		3			4			
95	3	765½	C	"	90			10	5			3			1	x		
	5	770½	C	"	60			40	2½			2			4			
	1	771½	C	"	100				12									end rail
	4½	776	C	cs		35		65		1½		1						
	10	786	C	"		85		15		3		1				x		
100	6	792	B	"		90		10		5		1			4	x		
	7½	799½	B					100				1						paper sh.
	3	802½	B	cs-f		5	tr	95		1		3						clay-rich
103	3½	806	CB	"	25	10		65	5½	1		3						iron rail at top cut
104	18	824	CB	"	10	20		70	2⅓	1⅓		3						clay-rich
105	17½	841½	CB	"		10	tr	90		1		3			4			clay-rich
106	5	846½	B	"	30	15		55	5	2		3	4		4			Pwr. pole, no number
107	16½	863	C	f	75	5		20	5	1½		3						
	4½	867½	C	cs		85		15		3		2			4			end rail
	11	878½	D	cs-f	40	30		20	6	2½		1		s	2			
110	6	884½	C			30		70		1½		2						argill.
	1½	886	C	cs-f	75	15		10	6	2		3			4			iron rail
112	12	898	C	"	10	30	tr	60	2½	2		3	4	s	1	x		silty shal
113	1½	899½	C	"	95			5	7			3						silty sh.
	5½	905	C	"		15	tr	85		1½		3			2			isol. foss
115	2½	907½	C	"	85			15	5½			3			4			
	9½	917	C	"	20	15		65	3	2		3		s	3			
	8	925	C	"	65	20		15	7	2½		2						
	9	934	CD	cs		10		90		2		2						
	1½	935½	C	cs-f	90			10	6½			1			2	x		
120	4	939½	CB				tr	100				3						
	1½	941	C	cs-f	75			25	5			3			4	x		
	4	945	C	"	15		tr	85	3			3			3			
	3½	948½	CD	"	75	10		15	10	1		3			4			
	4	952½	CD	"	100				48?									end rail
125	9	961½	CD	cs		35		65		2		3						landslide in cut
126	10½	972	CD	cs-f	85			15	6			3						Pwr. pole, no number
127	5	977	C	cs-f	95			5	12			1						
	28	1005	CD				10	90			3/4	3			3			

Stratigraphic Description — SHAMOKIN DAM SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
	1	1006	C	cs-f	100				12									
30	3½	1009½	C				10	90			3/4	3			2			
	12	1021½	C	cs-f	10	25	tr	65	2		3/4	3			1			
	13	1034½	C	"	30	15	10	45	4	2	3/4	3			2			
	10	1044½	C	"		10	15	75		1½	3/4	3	4		2			
	10½	1055	CD	"		10	5	85		1½	1/2	3			2			
35	14	1069	C	"	30	15	10	45	2½	1½	3/4	3	3		1			
	8½	1077½	C	"			10	90			1/2	3	2		1			
	5	1082½	C					100				3						clay-rich
	50½	1133	CB	cs-f		10	10	80		1½	3/4	3	3		1			silty shale
	8½	1141½	CB	"	10		20	70	3		3/4	3	4		2			iron rail
40	1	1142½	C	"	100				12						1			
	11	1153½	C	"	5		10	85	7		1/2	3			1			silty shale
	4½	1158	C	"	35		5	60	6		1/2	3	4		¼			silty shale
	19	1177	C	"			10	90			3/4	3	3		2			silty shale
	18½	1195½	C	"	25	10	10	55	7	1½	3/4	3	2		3			silty shale
45	20½	1216	C	"	5		5	90	7		1/2	3	3		4			silty shale
	34	1250	C	"	5		20	75	3½		3/4	3	1		3			
	12	1262	C	"	20	15	5	60	8	2	3/4	3			4			argill.
	33	1295	C	"	5	10	10	75	3	2	3/4	3	3	s	3			end rail
	11	1306	C	"	10	5	15	70	12	1½	1/2	3	2		4			
50	7	1313	CB	"	60	10	tr	30	9	3		3	3					laminated
	16	1329	CB	"			5	95			1/2	3			4			
	1½	1330½	C	"	90			10	8			3						
	9½	1340	C	"			5	95			3/4	3			4			argill.
	10½	1350½	C	"	50	15	tr	35	4½	3	3/4	3			4			
55	7	1357½	C	"			5	95			3/4	3						
56	7	1364½	CB	"	15			85	9			3						
57	6½	1371	CB	"			5	95			3/4	3			3			
	12½	1383½	CB	"	65	10	5	20	4	1½	3/4	2	3		3			
	14	1397½	C	"	5	30	5	60	1½	1	1/2	3			4			
60	4	1401½	CB	"	85			15	8½			3						laminated
	18	1419½	CB	"	5		10	85	3		3/4	3			3			clay-rich
	5½	1425	CB	"	15		10	75	1½		3/4	3			3	x		clay-rich
	7½	1432½	CB	"	20		10	70	3½		3/4	3			3	x		
	6	1438½	DCB	"	55			45	5			3			3			laminated
65	16	1454½	CB	"			15	85			3/4	3			2			
	13⅓	1468	CB	"	10		5	85	1½		3/4	3			3			clay-rich
	5	1473	CB	"	10		10	80	4		3/4	3			4			clay-rich
	13	1486	CB	"	5	20	tr	75	2½	3		3						clay-rich
	4½	1490½	CB	"	25			75	3			3	2					
70	8	1498½	CB	"			5	95			3/4	3			4			clay-rich
	4	1502½	CB	"	10		10	80	6		1/2	3	4		4			clay-rich
	4½	1507	CB	"			5	95			3/4	3	2		2	x		clay-rich
	9⅓	1516½	CB					100				3						
	2⅓	1519	CB	cs-f			10	90			3/4	3			2	x		

Stratigraphic Description — SHAMOKIN DAM SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
175	16	1535	CB	cs-f			5	95			1/2	3			3			clay-rich
	9	1544	CB	"	15		10	75	5		3/4	3			3			
	1½	1545½	C	"	100				18									
	7	1552½	CB	"	25	15	tr	60	4	2½		3						
	14	1566½	CB				tr	100				3	4					clay-rich
180	3½	1570	CI	cs-f	85			15	7			1						
	4	1574	CB				tr	100				3						
	4	1578	CB	cs-f	20		tr	80	3			3			4			clay-rich
	4	1582	CB	"	10		tr	90	1½			3						clay-rich
	1½	1583½	CI	"	100				18									laminated
185	8	1591½	CB	silty			tr	100				3						
	4	1595½	CB	cs-f	20			80	2½			3			1			laminated
	7	1602½	CB	"	10		tr	90	1½			3			3			
	8½	1611	CB	"	10		tr	90	2			3						
	2	1613	C	silty				100				3						
190	5	1618	CB	cs-f			5	95			3/4	3			4			clay-rich
	2½	1620½	CB	"	25			75	3½			3		s	2			laminated
	7	1627½	B	"	5			95	3			3		s				clay-rich
	13½	1641	CB	"	60			40	5			3		s				laminated
	35	1676	CB	"	15			85	3			3		s				clay-rich
195	19	1695	B					100				3						
	12	1707	CB	cs-f	10			90	4			3						
	246	1953																contorted covered
198	32	1985	C	cs-f	20			80	2½			2			4			behind cafe at traffic circle, s.of R.R. bridge over road
199	25½	2010½	CB	cs-f	40			60	8			2	4					
200	24½	2035	C	"	10			90	2			2						clay-rich covered, Harrell exposed W. of circle

Section 14, Catawissa

Section 14 in the Trimmers Rock was studied in cuts along the Pennsylvania Railroad north of the Borough of Catawissa and on the south side of the Susquehanna River across from the town of Bloomsburg. These excellent exposures occur in Catawissa Township, Columbia County on the Catawissa 7½-minute quadrangle.

Strata in the Catawissa section dip moderately south, and the railroad traverses them at an acute angle, so that the measured section is about 2 miles long. Moreover, the section is quite thick, totaling 2605½ feet between the lowest observed Catskill red bed and light-grayish-white Tully Limestone at the base.

The lowest red shales occur immediately south of the cross-over of the Reading and Pennsylvania railroad tracks, in a small bank behind the block operators shack, 4300′ north of 40°57′30″N and 1850′ west of 76°27′30″W. The section is covered for a stratigraphic interval of 253 feet below this, so that the red shales observed might not actually be the lowest present. Although it is occasionally necessary to climb the hillside the remainder of the section is essentially unbroken by covered intervals.

Ten feet of fossiliferous Tully Limestones are exposed at a point 4200′ south of 41°00′00″N and 4000′ east of 76°27′30″W, marking the base of the section. A long covered interval follows.

Because of the lack of topographic and cultural details to tie to for reference in measurement, an arbitrary numbering system for power poles along the tracks was utilized. Stratigraphic units measured in the field were then referred to the poles. Under this plan the first pole encountered after traversing the 253′ of covered interval at the top of the section is designated P.P.#1, the last one just above the limestone therefore being P.P.#61.

Stratigraphic Description					CATAWISSA SECTION													
Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
	4		red					100										Catskill,
																		at "Y" in
																		R.R. behin
																		shack
1	253	253																covered
																		poorly ex-
																		posed
	9	262	DI	cs-f	35			65	1½			2		s		x		R.R. cut
	9½	271½	DI	"	10			90	1			1			2			Pwr.pole 1
	1½	273	DI	"	100				9									N65E42S
5	3	276	DI	silty				100				2						
	3½	279½	C	cs-f	70			30	6			3	3	s	3			
	4½	284	G	cs		30		70		1		2	3	s				silty shal
	3	287	C	cs-f	15	10		75	2½	1½		1				x		
	8	295	C					100				1						silty shal
10	1½	296½	DI	cs-f	100				9					s		x		vague bdg.
	3½	300	C	silty				100				1						
	4	304	C	cs		70		30		3		3		s				
	4	308	DIC	cs-f	60	15		25	3½	2		1	2					vague bdg.
	11	319	G	"	10	25		65	2½	1½		1						vague bdg.
15	4½	323½	C					100				3						isol. foss
	4	327½	C					100				2						isol. foss
	28	355½	G	cs-f	15	30		55	3½	1½		2		s				Pwr.pole 2
	3½	359	DI	"	65			35	7			3	1	s				silicious
	7½	366½	DIC	"	45			55	4			2	1					
20	13	379½	GC	"	30	35		35	3	1½		2	2	s				sheared
	3	382½	C	silty				100				3						
	5	387½	C					100				3		s				isol. foss
	8	395½	C	cs-f			tr	100				2	1					
	22½	418	G	"	15	10		75	2	1		1	2	s				silty shal
25	6	424	G	"	25			75	4			2						silty shal
	7	431	G	"	10	30		60	1½	1½		3	4		4			Pwr.pole 3
	3	434	G	"	20	40		40	2½	1½		3		s				vague bdg.
	24	458	DI	"	35		10	55	3		½	1						
	10	468	GD	"	10			90	1			1						on hillsid
30	27½	495½	GD	"	10		10	80	2		3/4	1	2		2			in cut
	5½	501	GD	"	40			60	8			1						
	9½	510½	D	"	5			95	1½			1						
	14½	525	D	"	25		tr	75	3			1			4			Pwr.pole 4
	3	528	G	"			30	70			½	1			2			argill.
35	7	535	DI	"	40			60	5½			1		s		x		laminated
	7	542	D	"	25		tr	75	1½			1	2	s				
	11½	553½	DGI	"	35		5	60	7		3/4	1						
	4	557½	DI	"		30	5	65		1	½	3	4		4			on hillsid
	7	564½	DGI	"	30	5	tr	65	1½	1		3	4		3			in cut
40	5	569½	DGI	"	30		5	65	4		3/4	2	4		3			

Stratigraphic Description — CATAWISSA SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
	6	576½	DI	cs-f	10		5	85	1½		½	1		s				20% covered
2	3½	580	D	"	25			75	2			2				x		Pwr.pole 5
3	32	612	DI	"	15			85	2½			1		s	3	x		vague bdg.
	4	616	C	"	5			95	1½			2			3			
5	10½	626½	G	"	10	25	tr	65	3	1½		1		s		x		
	30	656½	CD	"	10	65		25	2½	1½		1		s				
	3½	660	CD	"	15	25		60	2½	1		1		s				Pwr.pole 6
	14½	674½	CD	"	10	20		70	5	1½		2		s				
	10	684½	DG	"	10	20		70	4	1½		2		s				
0	8½	693	DI	"	95			5	5			PTG	4	s				vague bdg.
	8	701	D	"	15	70		15	3	2		2	3	s				vague bdg.
	11½	712½	DC	vf-m	5	35		60	2½	2		3	4	s				grded. bdg.
	6	718½	D	cs-f	80			20	4			1		s				Pwr.pole 7
	2½	721	D	cs		30		70		1½		2						
5	11	732	D	cs-f	15	60		25	3	3		3	4					vague bdg.
	14	746	D	"	25	50		25	3	1		2	3	s				vague bdg.
	14½	760½	D	"	60	15		25	1½	2		3	4					vague bdg.
8	6½	767	D	"	30	10		60	1	1½		3		s	3	x		Pwr. pole 8
																		lite gantry
9	16	783	D	cs-f	5	60		35	3½	2		3		s				argill.
0	5	788	D	"	100				30				1					
	13	801	D	"	35	30		35	4½	2		3						vague bdg.
	14	815	D	"	60	10		30	6	2		2	2	s				argill.
	4	819	D	"	45			55	4			2						
	10⅓	829⅓	D	"	70			30	5			1	4	s				Pwr.pole 9
5	11	840⅓	D	"	35		10	55	2½		3/4	3	4	s	3	x		
	6	846½	D	"	80			20	8			2	1	s		x		
	11½	858	D	"	75			25	5			1	3	s				clay-rich
	15	873	D	"	65			35	6⅓			3		s				vague bdg.
	11½	884⅓	D	"	90			10	1⅓			3	3					vague bdg.
70	9½	894	D	"	60	20		20	5	2		3		s	4	x		Pwr.pole 10
	4½	898⅓	D	"	20	75		5	2	1½		3	4	s				
	5	903⅓	D	cs		10		90		1		1						
	12½	916	D	cs-f	5	45		50	3	2		2		s				argill.
	2	918	D	"	80			20	4			3	3					argill.
75	7	925	G					100				3		s				
	5	930	DG	cs-f	10			90	1⅓			2						clay-rich
	10	940	D	"	60			40	4½			2	2	s	4			Pwr.pole 11
	9	949	D					100				3						
	6½	955½	DC	cs-f	30			70	4			2		s				
80	4	959½	D	"	10		tr	90	3			2			4			
	3	962½	D	"	60			40	4			2				x	?	
	3	965½	D	"	20			80	3½			2						
	7	972½	D	"	75			25	2			3		s		x		argill.
	27	999½	D	"	15			85	3			3	4	s		x		Pwr.pole 12
85	10	1009½	D	"	60			40	3½			3	3			x		argill.

Stratigraphic Description					CATAWISSA SECTION													
Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Load Struc.	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
	3	1012½	D	cs-f	60			40	5			2				x		
87	4	1016½	DI	"	35			65	2			2						
88	4½	1021	DI	"	10			90	3			2			2	x		silty shal
	5½	1026½	DI	"	15			85	4			2						
90	5	1031½	DI	"	75			25	5			1	2					Pwr.pole 1
	8	1039½	DC	"	tr			100	3			3				x		silty shal
	16½	1056	D	"	40			60	5½			1	4	s		x		vague bdg.
	4½	1060½	D					100				3						
	14	1074½	CD	cs-f	25	25		50	5	1		1		s	4			Pwr.pole 1
95	10	1084½	CD	"	20			80	1½			2						clay-rich
	3½	1088	C					100				1						clay-rich
	2½	1090½	D	cs-f	50			50	6½			2				x		
	3½	1094½	CD	"	15			85	6			3		s				
	11	1105	C	"	10			90	2½			1						20% covere
100	2	1107	C	"	30			70	5			2				x	?	
	4	1111	CD	"	25			75	2½			1		s				
	24	1135	CD	"	30		tr	70	4½			1		s	4			Pwr.pole 1
	6	1141	C	"			tr	100				3						20% covere
	19	1160	D	"	35			65	9			1		L				
105	11½	1171½	D	"	40			60	7			3				x		Pwr.pole 1
	6	1177½	D	"	5	80		15	3	1		3		s	4			irreg.bdg.
	12½	1190	D	"	30			70	4			2				x	x	eroded bas
	4½	1194½	D	"		90	tr	10		1		2		s	3			
	1	1195½	D	"	100				9						3			
110	4	1199½	D	"		75	tr	25		1		2						
111	4½	1204	D	"	80			20	18			2				x	x	eroded bas
																		Pwr.pole 1
112	3	1207	DC	cs-f	75			25	12			1						
	4	1211	CD	"	30	10		60	5	2		1						clay-rich
	3½	1214½	C	cs		85		15		1½		3						
115	6	1220½	CD	cs-f	10			90	6			1				x	x	eroded bas
	4	1224½	C	cs		70		30		1		3						
	2	1226½	CD	cs-f	30			70	12			3				x	x	eroded bas
	13½	1240	CD	"	35	15		50	8	2		3			4	x		
	3	1243	C	"			5	95			3/4	3		s	4			Pwr.pole 18
120	4	1247	CD	"	40			60	9			3				x		on hillside
	12	1259	CD	"	30			70	6			2		s		x		in cut
	7	1266	C					100				3						
	1½	1267½	CD	cs-f	75			25	7			3						Pwr.pole 1
	6	1273½	C	"	10			90	9			3				x	?	
125	2	1275½	C	"	75	10		15	6	1		1						vague bdg.
	9	1284½	C	"	10			90	4			3			4	x		
	1½	1286	C	"	40			60	4			2				x	?	
	4½	1290½	C	"	5		5	90	1½		3/4	3						argill.
	2	1292½	CI	"	20			10	7			1		s				
130	5½	1298	CI	"	10			90	1½			3						silty shale

Stratigraphic Description — CATAWISSA SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Troce Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
	3½	1301⅓	D	"	30			70	5			2				x		
132	3½	1305	D	"	70		tr	30	9			1	4					Pwr.pole 20
133	30	1335	D					100				1						on hillside
																		clay-rich
134	62	1397	D	cs-f	10			90	2			1						in cut.
																		Pwr.pole 20
135	15½	1412⅓	CD	cs-f	60			40	8			3	4	s		x		vague bdg.
	8	1420⅓	CD	"	25			75	2½			2	4					clay-rich
	1½	1422	CD	"	50			50	7			2				x		
	15	1437	C	"	30			70	3			2				x		Pwr.pole 21
	11½	1448	D	"	60			40	12			2	1					
140	3	1451⅓	D	"	5		10	85	1⅓		3/4	3						silty shale
	4½	1456	D	"	50			50	4			1			4	x		vague bdg.
	8½	1464⅓	D	"	25			75	5			3		s		x		
	6⅓	1471	D	"	15			85	3			3	2					Pwr.pole 22
	22	1493	D	"	15		10	75	1⅓		3/4	3			2			on hillside
145	1	1494	D	"	100				12									in cut
	8	1502	D	f-m			15	85			3/4	3						grded.bdg.
	1	1503	D	cs-f	100				12									laminated
148	19	1522	D	f-m	10		20	70	2		3/4	3						graded bdg.
																		Pwr.pole 23
149	10	1532	D	cs-f	10			90	2⅓			2						
150	26	1558	D	"	30			70	4⅓			2						vague bdg.
	8	1566																covered
	19⅓	1585⅓	D	cs-f	65			35	6			2	4					Pwr.pole 24
	10	1595⅓	CD	"	20		tr	80	2⅓			3						22 milepost
	4⅓	1600	D	"	30			70	4			2						
155	4	1604	D	"	10			90	3			2				x		
	4	1608	D	"	10		tr	90	1⅓			3	4	s				clay-rich
	3	1611	D	"	50			50	2½			1		s				vague bdg.
	15	1626	D	"	20		15	65	2		3/4	3						Pwr.pole 25
	3⅓	1629⅓	D	"	90			10	10			1	4					silty shale
160	3⅓	1633	D					100				3						clay-rich
	7	1640	D	cs-f	35			65	5			2	2					
	13	1653	C	"		70	tr	30		2		2						
	3	1656	D	"	95			5	10			1	4	s				
	3⅓	1659⅓	D	"	70	20		10	2½	2		2						
165	5	1664⅓	D	"			15	85			3/4	3						
	2	1666⅓	D	"	95			5	6			1						
	2½	1669	D	"	30		10	60	2		½	3			4			
	4	1673	D	"	60			40	4⅓			3						Pwr.pole 26
	21	1694	D	"	15	25	5	60	2½	1	3/4	3						argill.
170	12	1706	D	"	5			95	2			2						
	2	1708	D	"	90			10	7			1						
	14	1722	C	"			tr	100				3						Pwr.pole 27
	11	1733	D	"	60			40	4			1		s				

Stratigraphic Description — CATAWISSA SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology I	% Lithology II	% Lithology III	% Lithology Sh	Average Bedding Thickness I	Average Bedding Thickness II	Average Bedding Thickness III	Fissility	Fossils	Trace Fossils	Cross Bed.	Lood. Struc.	Movement	Miscellaneous
	13½	1746½	D	cs-f	20	20	tr	60	4	1		3		s		x		vague bdg.
175	4½	1751	D	"		30	5	65		1½	3/4	3	4					
176	3	1754	D	"	60	10		30	6	1½		1						
	6	1760	D	"	35	15		50	3	1½		1						
	5	1765	DC	"	15	30		55	4	2½		1	4					
	9	1774	D	"	85			15	8			1	2	s				Pwr.pole 2
180	11	1785	D	"	10	20	5	65	3	1	3/4	3						
	6½	1791½	D	"	95			5	5			1						
	8½	1800	C	cs		25		75		1½		3						clay-rich
	6	1806	D	cs-f	35			65	6			3				x		
184	10	1816	D	"	25		5	70	2½		3/4	3						vague bdg.
																		Pwr.pole 2
185	13½	1829½	CD	cs-f	40			60	2½			2						vague bdg.
	14	1843½	D	"	30			70	8			1	4	s		x		vague bdg.
	6	1849½	D	"	40			60	5½			1						vague bdg.
	12½	1862	D	"	95			5	11			1		s				vague bdg.
189	15	1877	D	"	35			65	6			1				x		vague bdg.
																		Pwr.pole 30
190	7	1884	CD	cs-f	30			70	5			3		s		x		vague bdg.
	4½	1888½	C	"	5	10		85	2½	1½		3						
	33	1921½	D	"	65	20		15	12	2		3		s		x		Pwr.pole 31
	13	1934½	D	"	10		20	70	4		3/4	2						vague bdg.
	2	1936½	DC	"	80			20	10			1						
195	9	1945½	CD	"	15		10	75	3		3/4	1						vague bdg.
	5	1950½	C	"	35			65	2½			1						
	6½	1957	C	"	60	10		30	5	1		1	2	s				Pwr.pole 3
	6½	1963½	C	"	80			20	6			1						vague bdg.
	4½	1968	D	"	35			65	2½			2						vague bdg.
200	3½	1971½	D	"	85			15	9			1						vague bdg.
	6	1977½	D	"	40			60	5			2				x		vague bdg.
	11	1988½	CD	"	20		10	70	2		3/4	3						Pwr.pole 33
	20	2008½	CD	"	25			75	1½			3						
	13	2021½	CD	"	40		20	40	2½		3/4							Pwr.pole 34
205	12	2033½	CD	"	35	15	5	45	3	1½	3/4	2						laminated
	21	2054½	CD	"	25	10		65	7	1½		2						Pwr.pole 3
	11½	2066	CD	"	75			25	9			2		s				vague bdg.
	10½	2076½	CD	"	5	15	5	75	1½	1½	3/4	1						
	7½	2084	CD	"	50	15		35	3½	1½				s		x		Pwr.pole 3
210	23½	2107½	C	"			tr	100				2						clay-rich
	15	2122½	DC	"			10	90			3/4	3				x		Pwr.pole 3
	1	2123½	DC	"	95			5	6			3	4					
	4	2127½	C	"	5			95	1½			PTG						clay-rich
214	13	2140½	DC	"	50			50	5½			3		s				Pwr.pole 38
																		clay-rich
215	6	2146½	C	cs-f			10	90			3/4	3						
	1	2147½	D	"	100				4									

Stratigraphic Description — CATAWISSA SECTION

Unit No.	Thickness	Total Thickness	Color	Grain Size	% Lithology				Average Bedding Thickness			Fissility	Fossils	Trace Fossils	Cross Bed.	Load. Struc.	Movement	Miscellaneous
					I	II	III	Sh	I	II	III							
	6	2153½	CD	cs-f			15	85			3/4	3						argill.
218	1½	2155	D	"	100				6					s		x		
219	10	2165	DC	"	85			15	18			3		s		x		vague bdg.
																		Pwr.pole 39
220	10	2175	DC	cs-f	30	40		30	9	2½		3		s				Pwr.pole 40
																		Pwr.pole 41
221	11	2186	CD	cs-f	15			85	3			3						Pwr.pole 42
222	20	2206	CD	"	40			60	12			3						Pwr.pole 43
																		Pwr.pole 44
223	7	2213	C					100				3						clay-rich
	2	2215	D	cs-f	100				24									
225	25	2240	CD	"	50			50	20			3						Pwr.pole 44
																		Pwr.pole 45
226	14	2254	CD					100				2						silty shale
	13	2267	CD	cs-f	30			70	18			2						Pwr.pole 46
	5	2272	DC	"	90			10	14			1						vague bdg.
229	22	2294	C					100				2						clay-rich
																		Pwr.pole 47
230	3	2297	CD	cs-f	20			80	2			3						clay-rich
	7	2304	C					100				3						clay-rich
232	8	2312	C	cs-f	40			60	3½			2				x		Pwr.pole 48
																		clay-rich
233	4½	2316½	CD	cs-f	10			90	3			1			4			clay-rich
	3½	2320	D	"	90			10	7?			1		s				
235	32½	2352½	CB	"	5			95	2			1						Pwr.pole 49
																		clay-rich
236	2	2354½	D	cs-f	100				22?									
	18	2372½	CBD	"	5	15		80	3	1½		1				x		Pwr.pole 50
238	6½	2379	CBD	"	10			90	1½			2						clay-rich
239	6½	2385½	CBD	"	5			95	1½			1						clay-rich
240	10	2395½	CBD	"	15			85	2			3						Pwr.pole 51
241	15	2410½	B					100				1						Pwr.pole 52
																		clay-rich
242	15	2425½																covered
	25	2450½	B					100				1						Pwr.pole 55
	45	2495½	B					100				1						Pwr.pole 56
245	20	2515½	B					100				1						50% covered
																		Pwr.pole 57
246	15	2530½	BA					100				1						Milepost 23
	20	2550½	DI					100				1						Pwr.pole 58
	25	2575½	C					100				1						Pwr.pole 59
	15	2590½	CID					100				1						50% covered
250	5	2595½	DI					100				1						limey.
																		Pwr.pole 60
251	10	2605½						100				3						very limey, Tully (?)
																		Pwr.pole 61

APPENDIX B

The following tables contain measurements made on sedimentary structures; these observations include both dimensional and orientation data. They are tabulated by station and measurement unit.

Dimensional data are given under the headings "Length," "Width," and "Thickness" for a variety of structures, and under "Wave length" and "Amplitude" for ripple marks. Thickness has different meanings for different structures. For most structures thickness represents total relief normal to bedding, but for wedge outs the thickness value given is the maximum observed thickness of the lenticular bed.

Orientation data are given under the headings "Orientation" and "Current direction." The majority of structures do not yield current direction information because they are symmetrical. Thus, symmetrical ripple marks are oriented normal to current and groove-casts are oriented parallel to current, but further interpretation is not possible.

The structure described is designated by an "X" in the appropriate column. Discontinuous ripple marks are distinguished from continuous ones by a "D" in the "Ripple mark" column.

In the "Rating" column structures are designated excellent to poor by the numbers 1 through 4.

Sedimentary Structures															PORT JERVIS SECTION									
Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sond Body	Wedge-out	Bolster	Bolster, moved	Flame Struc	Deformed Bdg	Cord Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
2	x																	4	¼	150	240	4	asymmetric
3											x					30	18			100		1	slide block
8				x												1/16	1/16			170		2	on same bed
8			x												1	1/8	1/16			175		3	on same bed
15	x																	1½	½	120		2	
17				x											3	1/8	1/16			010		1	
18	x																	4½	½	060		2	on same bed
18				x											2	1/8	1/16			125		1	on same bed
18				x											1½	1/8	1/16			125		2	
19	x																	5	3/4	075		4	
27												x				1	½			100		2	axial plane
28							x								100	48	48			160		1	loaded
34									x						20	6	2			045		1	on same bed
34												x				4	2			045		1	on same bed
40	x																	5	3/4	040		4	
41												x				5	⅓			070		3	
42				x											½	1/8	1/16			025		3	
44	x																	2	½	075		4	
47									x							6	3			070		1	
49														x	2	1/8	1/8			050		1	average size
50									x						18	5	5			050		2	
50							x									6	2			060		2	
51									x						36	24	24			095		2	
63	x																	3	¼	165		3	
63	x																	2½	½	025	295	1	asymmetric
63	x																	2	¼	120		3	
66	x																	4	½	025		3	
66	x																	2	¼	175		2	
67												x				3	3/4			020		2	
68	x																	4	½	020		3	
69									x						60	36	24			105		2	
70	x																	4	½	120		3	
70	x																	3	3/4	120	210	2	asymmetric
70									x							3	2			125		3	on same bed
70	x																	3	¼	175		3	
73	x																	3	½	045		2	
73							x									1	1½			130		2	
73												x				2	½			030		1	
73	x																	2	¼	020		2	
73	x																	4	3/4	070		2	
78	x																	2	½	025		1	
80	x																	3	½	180		1	top of unit
80	x																	2	½	165		1	

Sedimentary Structures															PORT JERVIS SECTION									
Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Balster	Balster, moved	Flame Struc.	Deformed Bdg.	Card Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
80	x																	2	½	120	210	1	base of unit
																							asymmetric
88											x					3	2			105		2	on same bed
88									x						9	4	3			105		2	on same bed
88													x		2	½	¼			065		2	on same bed
89													x		3	⅓	¼			115		3	
94											x					9	12			040		2	
97			x												1¼	1/16	1/16			015		4	
106			x												5	½	1/16			120		3	
107											x					7	7			055		2	
107	x																	5	1	120		1	loaded
107												x				4½	1			060		2	
109												x				6	1½			100		1	
109											x					9	5			030		2	
109											x					12	12			050		1	
109													x		9	1	½			005		1	on same bed
109									x							3	3			005		3	on same bed
124													x		6	⅓	¼			015		1	
124											x					12	12			060		1	
124											x					6	3			070		2	
129											x					16	9			045		1	
132													x		6	⅓	⅓			010		1	on same bed
132											x					9	6			065		2	on same bed
138							x									3	3/4			065		3	
147											x					1½	6			075		2	
152							x									4	1			070		3	
166							x									10	1			060		3	

Sedimentary Structures															BUSH KILL SECTION								
Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg.	Cord Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Roting	Remarks
3	D																	5	3/4	150		3	
3	x																	5	3/4	120		4	
4									x						48	36	24			125		2	
12									x						36	12	8			145		1	
12													x		4	½	¼			055		2	on bolster
19													x			1	½			005		1	above
20	x																	3½	½	080		2	
20							x									8	1			035		2	
22									x						14	9	6			080		2	
24	x																	5	3/4	100		3	
26													x		7	1	3/4			085		2	on bolster
26									x						100	50	36			095		1	below
50			x												2½	1/16	1/16			075		3	
50	x																	2½	½	130	220	2	asymmetric
50	x																	9	1	080		3	loaded
55													x		4	½	¼			075		3	
59				x											½	1/8	1/16			005		4	
63	x																	6	½	160		3	
63			x												4	1/8	1/16			085		2	
63	x																	7	½	005	275	2	asymmetric
64	x																	3	½	035		3	
64			x												5	1/8	1/16			075		3	

Sedimentary Structures															BOWMANSTOWN SECTION								
Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg.	Cord Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
5	x																	4	½	070		3	
5							x									½	½			090		4	
6		x													1	½	¼			100	280	3	
7	x																	1½	¼	065	335	2	asymmetric
8	x																	3/8	1/8	025		1	
8	x																	3	½	040		4	
12							x									1	1			080		2	
14	D																	2½	½	055		4	lobate
14				x												¼	¼			075		2	
15	x																	2	¼	085	355	1	on shale
																							top
16	x																	8	½	070	340	1	on shale
21							x									½	½			065		2	top
21							x									3/4	3/4			065		2	loaded
31	x																	3½	3/4	085	355	1	asymmetric
35	x																	2	½	090	360	2	asymmetric
38							x									1½	1½			065		3	
43							x									3/4	1½			075		3	
46			x												4	¼	¼			085		2	Type II bed
56	x																	2	½	080		1	
59							x									1	1			090		2	
66	x																	4	1	095		4	
89			x												3	1/8	1/8			050		1	Type II bed
94		x													3	½	½			050	260	1	Type II bed
99			x												2	1/8	1/8			085		2	Type II bed
116			x												7	1/8	1/8			075		3	Type II bed
116			x												1½	1/8	1/8			075		1	

Sedimentary Structures — NEW RINGGOLD SECTION

Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg.	Cord Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
16	D																	4	1	085		3	
20	x																	3½	½	080		4	
21	D																	8	3/4	100		4	loaded
26	x																	6	3/4	085		2	
32	D																	4½	1	075		3	loaded
51			x												1	1/16	1/16			085		4	
59			x												4	1/8	1/16			085		3	
67									x						10	1	½			080		4	
75	x																	2	¼	100		4	
78	x																	2	½	095		4	
82									x						10	6	2			065		2	
84	x																	5	3/4	150		3	
86	D																	4½	½	085		4	loaded
92	x																	3½	½	010		2	peaked crests
93	x																	4	¼	175		3	
94	x																	3½	½	040		2	peaked crests
94	x																	3	½	035		2	peaked crests
99	x																	2½	½	095		2	
100	x																	7	3/4	065		3	
100	x																	2½	½	165		4	
109	x																	3	½	105		3	
110	x																	4	½	080		2	
117	x																	3½	½	095		3	
126	x																	5	1	075		4	loaded
130	x																	3	½	140	0501		asymmetric
132	x																	5	½	080		4	
137	x																	3	½	035		2	
140	x																	3	3/4	085		3	

Sedimentary Structures — SCHUYLKILL HAVEN SECTION

Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg.	Cord Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
7			x												2½	1/8	/16			155		4	
19			x												1	1/16	1/16			105		4	
32	x																	5	½	140		3	
47			x												26	2	1			095		1	loaded
70	x																	1½	½	065		3	loaded on sandstone
84													x		8	½	¼			110		2	
90			x												7	1/16	1/16			100		2	20"sandstone
106	x																	3½	¼	155		4	

MARYSVILLE SECTION

Unit No.	Sedimentary Structures: Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg.	Cord Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
57		x													1¼	½	3/8			070	070	3	on bolster
																							below
57										x					20	12	8			020		2	
64			x												2	¼	1/8			045		1	
74									x						8	6	6			090		2	
79									x						9	12	16			040		2	
79									x						24	14	10			075		3	
79									x						14	11	7			060		2	
79									x						48	12	6			045		3	
80					x										½	1/8	1/8			050	230	4	
91									x						24	9	7			055		3	

Sedimentary Structures														DROMGOLD SECTION								
Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sond Body	Wedge-out	Bolster	Bolster, moved	Flome Struc.	Deformed Bdg.	Cord Struc.	Plant Frog	Length	Width	Thickness	Wove Length	Amplitude	Orientotion	Current Direction	Roting	Remarks
3							x									5	2½			045		1	
11								x									4			010		3	zero to North
11									x							6	4			050		2	
11	x																	3	3/4	030		3	
11				x											6	½	1/8			165		1	
21	x																	3	1	025		4	
25			x												1	1/8	1/8			165		3	
33				x											½	1/8	1/16			005		2	
53										x					10	7	5			160		2	
53										x						12	6			035		2	
53										x						18	8			055		2	overturned
57									x						15	6	3			055		2	
59												x				5	1			070		1	axial plane
60								x									3			010		3	zero to North
65	x																	9	3/4	085		4	
65												x				4	1			085		2	axial plane
66	x																	3/4	½	040		1	
67											x					4	9			025		2	
72							x									10	5			050		1	
72												x				8	1			075		2	axial plane
73								x									18			065		1	zero to North
74									x						17	9	6			055		2	
74												x				6	4			150		2	axial plane
81	x																	3	½	030	300	4	asymmetric
87	x																	4	½	065		3	
108							x									4	1			105		2	
114			x												1	1/16	1/16			105		2	
123					x										½	¼	¼			110	290	3	
125		x													2	½	¼			080	260	3	

Sedimentary Structures															GIRTYS NOTCH SECTION								
Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sond Body	Wedge-out	Bolster	Bolster, moved	Flame Struc	Deformed Bdg	Cord Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Roting	Remarks
1	x																	3½	3/4	070		4	
2	x																	1	¼	020		3	
3		x													3	½	¼			025	025	2	
9								x									6			080		4	zero to North
13												x				12	6			075		2	axial plane
17												x				8	5			060		2	axial plane
17								x									1			090		1	zero to South
18									x							4	1			070		1	on same bed
18	x																	3½	1½	070		1	on same bed
21								x									8			080		2	zero to North
22	x																	1½	3/8	085		2	
22				x												1/8	1/8			080		2	
30	D																	4	1	065		3	
50			x												2	1/8	1/8			115		3	
51			x												2	1/16	1/16			120		2	
53					x										½	1/8	1/16			085	265	4	
55	x																	2	½	040		4	
56								x									1½			100		1	zero to North
60												x				1				105		2	
62	x																	4	½	135		1	Type II bed
67			x												3	1/8	1/8			110		2	
69			x												1	½	1/8			165	345	2	chevrons
70			x												1½	1/16	1/16			115		1	
71	x																	3½	½	010		4	
84	x																	2½	¼	100		4	
90	x																	2½	¼	040		2	
93	x																	5	3/4	110		1	loaded
96	x																	4½	½	060		3	
100	x																	3½	½	050		3	
105								x									1½			085		2	zero to South
107			x												1	1/8	1/8			155		2	
109	x																	1½	½	065	335	2	asymmetric
116								x									2			100		3	zero to South
117								x									1			065		1	zero to North
118			x												6	1/8	1/16			120		1	
118			x												24	1	½			115		1	
124	x																	7	3/4	040		1	
129				x												3/16	1/16			020		1	
130			x												6	½	1/16			105		4	

GIRTYS NOTCH SECTION

Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg	Cord Struc.	Plant Frag	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
134			x												3	½	1/16			090		4	Type II bed
162								x									2			065		2	zero to North
167	x																	4	½	040		4	
167												x				1	1			090		2	axial plane
171												x				1				065		1	axial plane
173	x																	2	¼	035		3	
175			x												2	1/16	1/16			115		2	
180			x												8	½	¼			100		1	
182			x												1	1/16	1/16			105		3	
200			x												2	1/8	1/16			100		3	

JUNIATA RIVER SECTION

Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc	Deformed Bdg	Cord Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
4							x									2	1			050		3	
48	x																	3½	½	025		2	loaded
49	x																	4	3/4	030		2	
52	x																	3	3/4	045		1	loaded
63			x												4	1/16	1/16			075		2	
64		x													6	3⅓	1			080	260	1	loaded
73			x												3⅓	1/16	1/16			080		2	
87									x						40	24	16			105		1	
94			x												11	1	½			140		2	
108			x												1	1/16	1/16			100		3	
108	x																	5	1	065		2	
108	x																	8	3/4	075		4	
168			x												2⅓	1/16	1/8			100		2	
179			x												9	3/4	½			095		2	

MILLERSTOWN SECTION

Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg.	Cord Struc.	Plant Frag	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
6			x												1½	1/16	1/16			090		3	
11												x								090		2	axial plane
33									x							3	2			065		3	
33													x		3	¼	½			075		2	
63		x													3	½	½			115	295	1	loaded
72			x												1½	1/8	1/8			120		3	
89			x												1	1/16	1/16			125		3	

Sedimentary Structures															LIVERPOOL SECTION								
Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg.	Cord Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
12			x												1	1/8	1/16			150		2	
12								x									6			095		4	zero to North
15			x												14	1/8	1/16			120		2	
16									x							2	2			075		4	
17	x																	2½	½	060		3	
18	x																	3	½	075		1	
20												x								060		3	axial plane
20											x					3	9			060		2	
24									x						10	5	3/4			070		2	
24											x					4	6			070		2	
27	x																	6	3/4	055		4	
31	x																	6	1	080		2	loaded
31	x																	1	¼	075		2	
31	x																	2½	½	065		2	
33										x					6	3	1½			040		1	
33										x						6	3			055		3	
39							x									7	1½			080		1	
45											x					4	2			065		1	
45			x												2	1/8	1/16			135		2	
46												x			12	1/8				075		2	
48												x								060		3	
48	x																	2	¼	065		1	
51	x																	3	⅓	050		2	
53			x												2	1/8	1/16			100		3	
55			x												3	1/8	1/8			110		3	
63	x																	4½	½	060		1	
63	x																	4½	½	085		2	
83	x																	6	1	060		1	loaded
85	x																	5	½	065		2	
88	x																	7	1	075		1	loaded
95	x																	2½	½	060	330	1	asymmetric
95	x																	5	½	065	335	2	asymmetric
96	x																	6	1	065		1	
96							x											8	1	065		1	loaded
98	x																	5	3/4	080		3	loaded
103			x												18	1½	½			100		1	
103	x																	4½	½	050		2	
103	x																	4	¼	060		3	
119	x																	3	¼	175		4	
121	x																	3½	½	055		3	
125							x									6	1½			065		3	
125								x									2			065		3	zero to North
140	x																	5	3/4	070		2	

Sedimentary Structures — LIVERPOOL SECTION

Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg.	Card Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
146		x													1½	½	¼			070	250	4	Type II bed
151	x																	5	½	055		4	
167	x																	6	¼	050		4	
177			x												1	1/8	1/8			075		3	

Sedimentary Structures — RED CROSS SECTION

Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg.	Card Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Rating	Remarks
14			x												3	1/16	1/16			090		3	
18		x													1	1/8	1/8			080	260	2	
22		x													2	¼	1/8			100	280	1	
26							x									2	1½			090		3	
39			x												2	¼	3/16			080		3	
42									x						9	2	6			100		3	
86			x												1	1/8	1/8			110		3	

Sedimentary Structures															SHAMOKIN DAM SECTION								
Unit No.	Ripple Mark	Flute Cost	Groove Cost	Furraw Cost	Prod cast	Cross Strat.	CS Sond Body	Wedge-out	Bolster	Balster, moved	Flame Struc.	Deformed Bdg.	Card Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Roting	Remarks
10			x												4	½	1/8			130		2	
12			x												2	¼	1/8			140		2	
18							x									2	1			080		4	
23							x									2	2			080		4	loaded
25							x									2	2			080		4	
26	x																	2½	3/4	080		2	
26	x																	3	½	110		2	
47							x								9	4	4			045		2	
48							x								10	6	3			115		1	
52			x												2	¼	1/16			145		2	
53		x													5	2	½			140	320	4	
53	x																	4	3/8	095		3	
57			x												8	1/16	1/16			120		2	
62			x												2½	1/8	1/16			110		2	
64		x													2	½	½			130	310	2	
64	x																	3	½	065		4	
68			x												3½	1/16	1/16			055		2	
68					x										½	1/8	1/8			055	235	4	
68		x													3	1	1			170	350	1	loaded
78	x																	3	½	130		1	
83			x												5	1/16	1/16			125		2	
85	x																	1½	½	065		4	
93	x																	2	½	070		4	
98	D																	4	½	125		2	
98			x												2	3/8	½			125		1	
99			x												9	½	½			115		2	
101			x												1½	1/16	1/16			130		2	
107	x																	2½	½	085		4	
109	x																	3	½	100		3	
116	D																	6	½	110		4	
123	x																	14	2	080		1	
124			x												14	½	½			065		1	
124	x																	12	3/4	090		1	
133			x												4	1/16	1/16			105		3	
136	x																	2	½	075		1	loaded
137			x												5	1	½			075		2	
148	x																	5	1	110		3	loaded
150			x												3	½	½			075		2	
154			x												7	½	½			110		3	
156			x												4	1/8	1/16			130		4	
169			x												4	1/8	1/16			080		2	
178			x												1½	1/16	1/16			090		3	
186			x												9	1/16	1/16			100		2	
187			x												6	3/8	½			115		2	
193		x													2½	1	½			070	250	2	
194			x												3½	1/8	1/16			080		1	
195			x												2	1/16	1/16			080		3	

Sedimentary Structures															CATAWISSA SECTION								
Unit No.	Ripple Mark	Flute Cost	Groove Cast	Furrow Cost	Prod cost	Cross Strot.	CS Sond Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg	Cord Struc.	Plant Frog.	Length	Width	Thickness	Wove Length	Amplitude	Orientotion	Current Direction	Roting	Remarks
2												x								075		3	
2	x																	2½	½	105		2	loaded
19	x																	3	¼	100		1	
19									x							4	1			095		1	
35			x												4	½	1/8			110		3	
36												x				1½	½			100		3	
37			x												5	¼	1/16			100		2	Type II bed
42	x																	6	½	085		2	
44			x												5½	1/16	1/16			095		1	
45			x												1½	1/16	1/16			110		3	Type II bed
46					x										1	1/8	1/8			110		2	Type II bed
55			x												6	¼	1/16			105		3	
63	x																	5	3/4	065		4	
64											x					1	2			090		4	
65									x						36	2½	1½			100		2	
67	x																	7	½	155		3	
68		x													2	½	¼			080	260	2	
78			x												3	1/8	1/16			080		3	
87	x																	4	3/4	100		1	on base bolster
88												x				4	2			070		2	
95												x				5	3			065		2	
96									x						9	7	3			085		3	
99											x					4	3			080		4	
101			x												4	3/8	1/8			100		1	
101			x												10	½	1/8			110		1	base of shale
103												x				1	1/16			085		1	
104									x						9	6	2½			080		1	
106											x					3	5			105		1	
107							x								60	35	18			080		1	
109							x									5	1½			130		2	
116	x																	5	1	080		1	on bolster
117	x																	4	½	070		3	loaded
118									x							9	7			075		2	
123									x							12	6			115		3	
131	x																	8	1	095		3	loaded
139		x													2	½	¼			125	305	2	
143		x													3	½	¼			160	340	4	
179	x																	4	½	095		3	
188	x																	1	¼	100		4	
189	x																	5	1½	100		2	
192			x												1	¼	1/16			175		4	
202			x												3	¼	1/16			105		4	
208	x																	6	½	085		2	loaded
216			x												7	¼	1/8			095		2	

Sedimentary Structures — CATAWISSA SECTION

Unit No.	Ripple Mark	Flute Cast	Groove Cast	Furrow Cast	Prod cast	Cross Strat.	CS Sand Body	Wedge-out	Bolster	Bolster, moved	Flame Struc.	Deformed Bdg.	Cord Struc.	Plant Frag.	Length	Width	Thickness	Wave Length	Amplitude	Orientation	Current Direction	Roting	Remarks
218		x													2	½	1/8			085	265	2	
218			x												3½	1/8	1/8			080		2	
219			x												4	1/16	1/16			100		2	
219					x										1	½	1/8			100	280	3	
227			x												5	1/8	1/16			110		2	
236			x												3	1/16	1/16			095		2	

APPENDIX C

The tables of Appendix C contain grain-size measurements made on six thin-sections examined for the presence of graded bedding. The data are tabulated by grain-size in phi units and by traverse number. For all thin-sections, Traverse 1 is at the bed base.

Mean size and standard deviation were calculated and are included at the bottom of the tables. The numerical counts are given at the left side of the table and these are converted to percentage frequencies on the right side.

GRAIN SIZE (Φ)	OCCURRENCES IN TRAVERSE								PERCENTAGE IN TRAVERSE							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
6–5	15	14	18	39	59	112	157	236	8	8	12	20	28	39	51	54
5–4	53	54	45	59	82	98	71	121	27	31	29	30	38	33	24	28
4–3	93	78	72	82	67	79	73	71	47	44	47	41	31	27	24	16
3–2	31	30	19	19	7	3	4	7	17	17	12	10	3	1	1	2
2–1	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
TOTAL	193	176	154	199	215	292	305	435	100	100	100	101	100	100	100	100
MEAN SIZE (Φ)	3.74	3.80	3.91	4.10	4.41	4.60	4.75	4.84								
STD. DEV. (σ_Φ)	.86	.84	.85	.92	.84	.83	.85	.81								

Distribution of quartz grain-size in thin-section P-101 by frequency per traverse and percent per traverse.

GRAIN SIZE (Φ)	OCCURRENCES IN TRAVERSE			PERCENTAGE IN TRAVERSE		
	1	2	3	1	2	3
6–5	107	84	93	36	36	41
5–4	90	69	75	31	30	33
4–3	87	74	51	30	32	23
3–2	9	5	5	3	2	2
TOTAL	293	232	224	100	100	99
MEAN SIZE (Φ)	4.50	4.50	4.64			
STD. DEV. (σ_Φ)	.89	.88	.84			

Distribution of quartz grain-size in thin section AH-101 by frequency per traverse and percent per traverse.

GRAIN SIZE (Φ)	OCCURRENCES IN TRAVERSE 1	2	3	4	PERCENTAGE IN TRAVERSE 1	2	3	4
5–4	23	23	35	68	22	27	31	47
4–3	21	15	18	41	20	18	16	29
3–2	25	14	32	25	24	17	28	17
2–1	31	31	28	11	30	37	25	8
1–0	2	1	0	0	2	1	0	0
0–(–1)	1	1	0	0	1	1	0	0
TOTAL	103	85	113	145	99	101	100	101
MEAN SIZE (Φ)	1.78	1.79	3.03	3.64				
STD. DEV. (σ_Φ)	1.22	1.31	1.17	.96				

Distribution of quartz grain-size in thin-section SD-72 by frequency per traverse and percent per traverse.

GRAIN SIZE (Φ)	OCCURRENCES IN TRAVERSE 1	2	3	4	PERCENTAGE IN TRAVERSE 1	2	3	4
6–5	116	113	153	244	55	65	72	88
5–4	75	49	56	31	35	28	26	11
4–3	21	12	5	4	10	7	2	1
3–2	1	0	0	0	1	0	0	0
TOTAL	213	174	214	279	101	100	100	100
MEAN SIZE (Φ)	4.94	5.08	5.19	5.36				
STD. DEV. (σ_Φ)	.69	.62	.51	.39				

Distribution of quartz grain-size in thin-section SH-73 by frequency per traverse and percent per traverse.

GRAIN SIZE (Φ)	OCCURRENCES IN TRAVERSE 1	2	3	4	PERCENTAGE IN TRAVERSE 1	2	3	4
6–5	38	64	91	140	24	29	38	76
5–4	32	63	85	34	20	28	35	19
4–3	66	77	56	8	42	35	23	4
3–2	21	19	9	2	13	9	4	1
2–1	1	0	0	0	1	0	0	0
TOTAL	158	223	241	184	100	101	100	100
MEAN SIZE (Φ)	4.04	4.27	4.57	5.20				
STD. DEV. (σ_Φ)	1.02	.96	.87	.60				

Distribution of quartz grain-size in thin-section NR-56 by frequency per traverse and percent per traverse.

GRAIN SIZE (Φ)	OCCURRENCES IN TRAVERSE 1	2	3	4	5	PERCENTAGE IN TRAVERSE 1	2	3	4	5
7–6	39	48	37	52	45	17	18	16	21	19
6–5	98	111	113	139	139	42	42	47	56	58
5–4	65	76	68	45	49	28	28	29	18	21
4–3	29	27	17	10	7	12	10	7	4	3
3–2	3	4	0	1	0	1	2	0	1	0
TOTAL	234	266	235	247	240	100	100	99	99	101
MEAN SIZE (Φ)	5.11	5.14	5.23	5.43	5.43					
STD. DEV. (σ_Φ)	.95	.94	.81	.76	.71					

Distribution of quartz grain-size in thin-section AH-102 by frequency per traverse and percent per traverse.

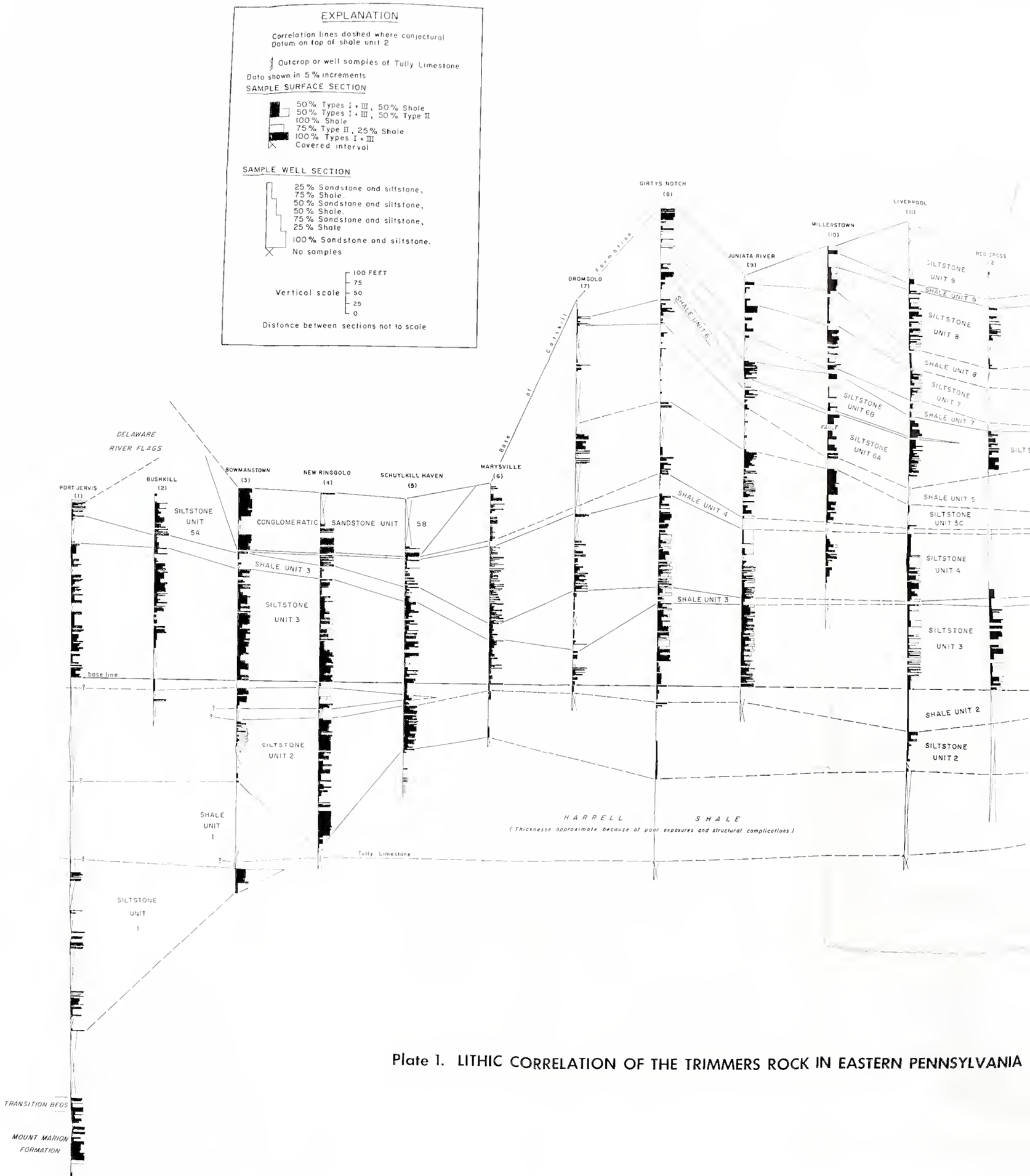
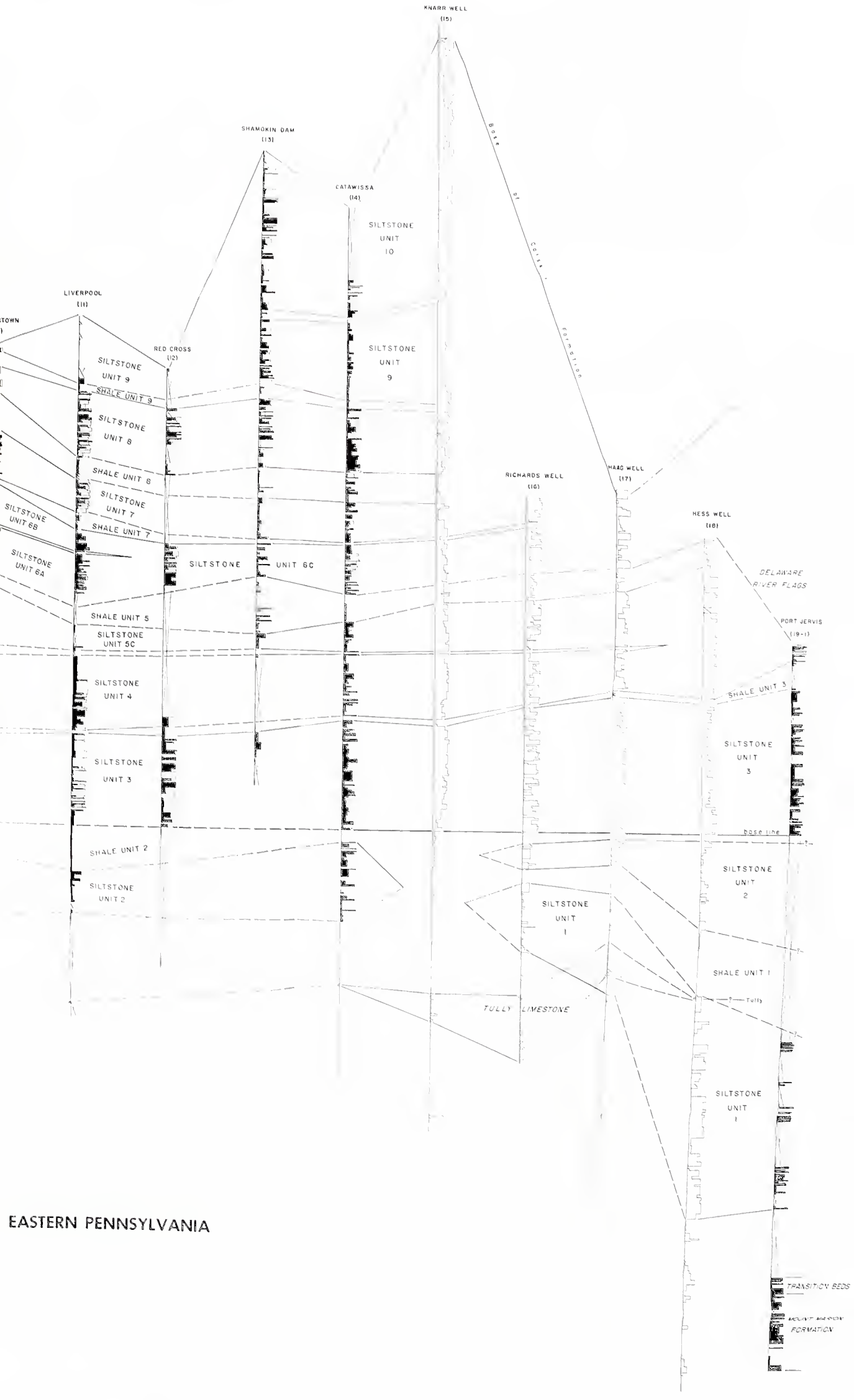


Plate 1. LITHIC CORRELATION OF THE TRIMMERS ROCK IN EASTERN PENNSYLVANIA



EASTERN PENNSYLVANIA